

Small, High-Spired Pulmonates from Mounts Mahermana, Ilapiry, and Vasiha, Southeastern Madagascar, with Description of a New Genus, and with Conservation Statuses of 15 Streptaxid Species

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Abstract. Quantitative, replicated altitudinal transects on the three mountains yielded 20 small, high-spired pulmonate species in seven genera in three families. Descriptions are given of the two orculids *Fauxulus andohahelae* sp. nov. and *F. gaillardi* Fischer-Piette, Blanc, Blanc & Salvat, 1994; of the three subulinids *Curvella vohimena* sp. nov., *Opeas tsiveryi* sp. nov., and *Subulina mamillata* (Craven, 1880); and of the 15 streptaxids *Gulella benjamini* sp. nov., *G. minuscula* sp. nov., *G. reeae* sp. nov., *Parvedentulina* gen. nov. *acutapex* sp. nov., *P. apicostrata* sp. nov., *P. esetra* sp. nov., *P. latembryohelix* sp. nov., *P. mahialamboensis* sp. nov., *P. margostrata* sp. nov., *P. ovatostoma* sp. nov., *P. rogeri* sp. nov., *Streptostele (Makrokouche) bougieformis* sp. nov., *S. (M.) latapex* sp. nov., *S. (M.) magnapex* sp. nov., and *S. (M.) vohimenensis* sp. nov. Description of *Parvedentulina* gen. nov. includes three new combinations: *P. glessi* (Fischer-Piette, Blanc, Blanc, & Salvat, 1994) comb. nov.; *P. metula* (Crosse, 1881) comb. nov.; and *P. simeni* (Fischer-Piette, Blanc, Blanc, & Salvat, 1994) comb. nov.

Streptaxids are a major component (17% on average) of the snail fauna in southeastern Madagascar, although not to the extent that they are in mainland-African rainforests (e.g. average 25%, maximum approx. 50% in eastern Tanzania).

Distributional data indicate that, of the 15 streptaxid species, five are Critically Endangered and 10 are Endangered.

INTRODUCTION

This paper is the second in a series of four that identify and describe the species reported on as morphospecies by Emberton et al. (1996, 1999) and Emberton (1997). This paper treats the Mahermana-Ilapiry-Vasiha small, high-spired pulmonates; and it evaluates each streptaxid species for conservation status.

METHODS AND MATERIALS

Collecting methods have been detailed by Emberton et al. (1996). Sixteen stations were collected and numbered in the "Tol" series (for Tolagnaro = Fort Dauphin, the nearest city). These stations have been mapped by Emberton et al. (1996, 1999) and by Emberton (1997). To shorten the taxonomic descriptions, stations are described briefly below. Station numbers are in the series of the Molluscan Biodiversity Institute (MBI). All stations were restricted to primary forest that had no more than limited selective cutting. Ecological data are given by Emberton (1997:table 1). All stations are in Madagascar: Tulear

Province. Mount Mahermana (Vohimena Chain) is north-east of the village of Esetra, Ilapiry (Vohimena Chain) is west of Mahialambo, and Vasiha (Anosy Chain) is west of Malio. Latitude and longitude are given in degrees, minutes, and seconds.

MBI 373 (= Tol-1). Summit of Mt. Mahermana, 340 m, 24°26'12"S, 47°13'13"E.

MBI 374 (= Tol-2). Slope of Mt. Mahermana, 300 m, 24°26'17"S, 47°13'10"E.

MBI 375 (= Tol-3). Slope of Mt. Mahermana, 200 m, 24°26'15"S, 47°13'04"E.

MBI 376 (= Tol-4). Valley on Mt. Mahermana, 100 m, 24°26'22"S, 47°12'41"E.

MBI 377 (= Tol-5). Summit of Mt. Ilapiry, 540 m, 24°51'40"S, 47°00'20"E.

MBI 378 (= Tol-6). Ridge on Mt. Ilapiry, 500 m, 24°51'33"S, 47°00'27"E.

MBI 379 (= Tol-7). Ridge, valley, and slope on Mt. Ilapiry, 400 m, 24°51'27"S, 47°00'38"E.

MBI 380 (= Tol-8). Slope of Mt. Ilapiry, 300 m, 24°51'36"S, 47°00'40"E.

MBI 381 (= Tol-9). Slope of Mt. Ilapiry, 200 m, 24°51'39"S, 47°00'46"E.

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Table 1

Shell and reproductive characters used in descriptions.

SHELL

1. Diameter (0.1 mm)
2. Height (0.1 mm)
3. Height/Diameter
4. Aperture mid-width (perpendicular to rotational axis)/shell diameter (0.1)
5. Aperture mid-height (parallel to rotational axis)/aperture width (0.1)
6. Width between upper and lower insertions of the peristome/aperture mid-width
7. Whorl number (0.1)
8. Coiling tightness (whorl number/ln height)
9. Apex angle (degrees)
10. Spire angle (degrees)
11. Barrelling: outward departure from straight line of whorls between $n-0.5$ and approximate second whorl (% shell diameter)
12. Parietal and palatal dentition (no, yes)
13. Columellar dentition (no, yes)
14. First whorl diameter (mm)
15. Early coiling tightness ($2/\ln$ diameter of first two whorls)
16. Apical sculpture
17. Transverse rib density (number in seventh or eighth 0.1 of body whorl)
18. Rib height (% shell diameter)
19. Diminishment of rib sculpture toward apex (%)
20. Shape of the suture (simple, shouldered, canalicate)
21. Density of sutural notches (same as density of transverse ribs, $\frac{2}{3}$ density of transverse ribs)
22. Umbilicus, regardless of columella (minute, imperforate or nearly so)
23. Columella reflection (slight, strong and flat, strong and rolled)
24. Sculpture other than transverse ribs

REPRODUCTIVE SYSTEM

25. Penis length (mm)
26. Penis width (range in mm)
27. Penial sheath (incorporating loop of vas deferens) (yes, no)
28. Penial sheath height (mm)
29. Penial apical caecum (yes, no)
30. Apical caecum height (mm)
31. Penial general sculpture
32. Penial retractor muscle attachment point
33. Epiphallus (yes, no)
34. Vas deferens width(s)
35. Atrium approximate size
36. Vagina length
37. Spermathecal duct width
38. Spermatheca-plus-spermathecal-duct length
39. Oviduct contents (egg, embryo, nothing)
40. Oviducal-embryo whorl count (0.1)

MBI 382 (= Tol-10). Lower summit of Mt. Vasiha, 860 m, 24°55'18"S, 46°44'19"E.

MBI 383 (= Tol-11). Slope of Mt. Vasiha, 700 m, 24°55'23"S, 46°44'27"E.

MBI 384 (= Tol-12). Slope of Mt. Vasiha, 500 m, 24°55'19"S, 46°44'45"E.

MBI 385 (= Tol-13). Valley on Mt. Vasiha, 400 m, 24°55'25"S, 46°44'45"E.

MBI 386 (= Tol-14). Slope of Mt. Vasiha, 300 m, 24°55'37"S, 46°44'49"E.

MBI 387 (= Tol-15). Slope of Mt. Vasiha, 200 m, 24°56'13"S, 46°45'13"E.

MBI 388 (= Tol-16). Slope of Mt. Vasiha, 100 m, 24°56'20"S, 46°46'07"E.

MBI 389 (= Tol-3-4). Incidental collecting between Tol-3 and Tol-4.

MBI 390 (= Tol-1-2). Incidental collecting between Tol-1 and Tol-2.

MBI 391 (= Tol-sub-5). Incidental collecting below summit of Mt. Ilapiry, Tol-5.

MBI 392 (= Tol-7-9). Incidental collecting between Tol-7 and Tol-9.

Species identifications and comparisons were made using Fischer-Piette et al. (1994) and Emberton (1994).

For each species, the holotype or a representative shell was photographed in standard views. Orculids were photographed at 16× magnification in apertural, side, and basal views; subulinids in apertural view at 6.4× or 25× and in subapical view at 40×; and streptaxids in apertural view (6.4×, 10×, 16×, 25×, or 40×), in apical view at 40×, and—for *Streptosteles* only—in side view showing penultimate and body whorls at 40× and sometimes in basal view at 40× (Figures 2–25).

Twenty-four shell characters (Table 1, Figure 1) were measured, or measured and calculated, or scored from the photographs or from the shells themselves.

At least one adult anatomy was available for eight species: one orculid, one subulinid, and six streptaxids. From each of these species, one or two reproductive systems were removed and photographed as they were turned and progressively dissected to expose characters. Sixteen reproductive-anatomical characters (Table 1, Figures 26–35) were taken from the drawings or from the dissections themselves.

Character matrices were prepared and used to code character-state data into the DELTA system (Partridge et al., 1993; Dallwitz et al., 1993), which was then used to generate natural-language species shell descriptions. The remainder of the descriptions were completed manually.

For each streptaxid species, conservation status was evaluated using the new categories and criteria of the International Union for the Conservation of Nature and Natural Resources (IUCN, 1996). Ranges were estimated from distribution data in Emberton (in press). Rainforest extent and decline were assessed using Green & Sussman (1990), Sussman et al. (1994), and the most recently available topographic maps.

SYSTEMATICS

Higher classification follows Ponder & Lindberg (1997), Nordsieck (1986), and Vaught (1989). Type materials are

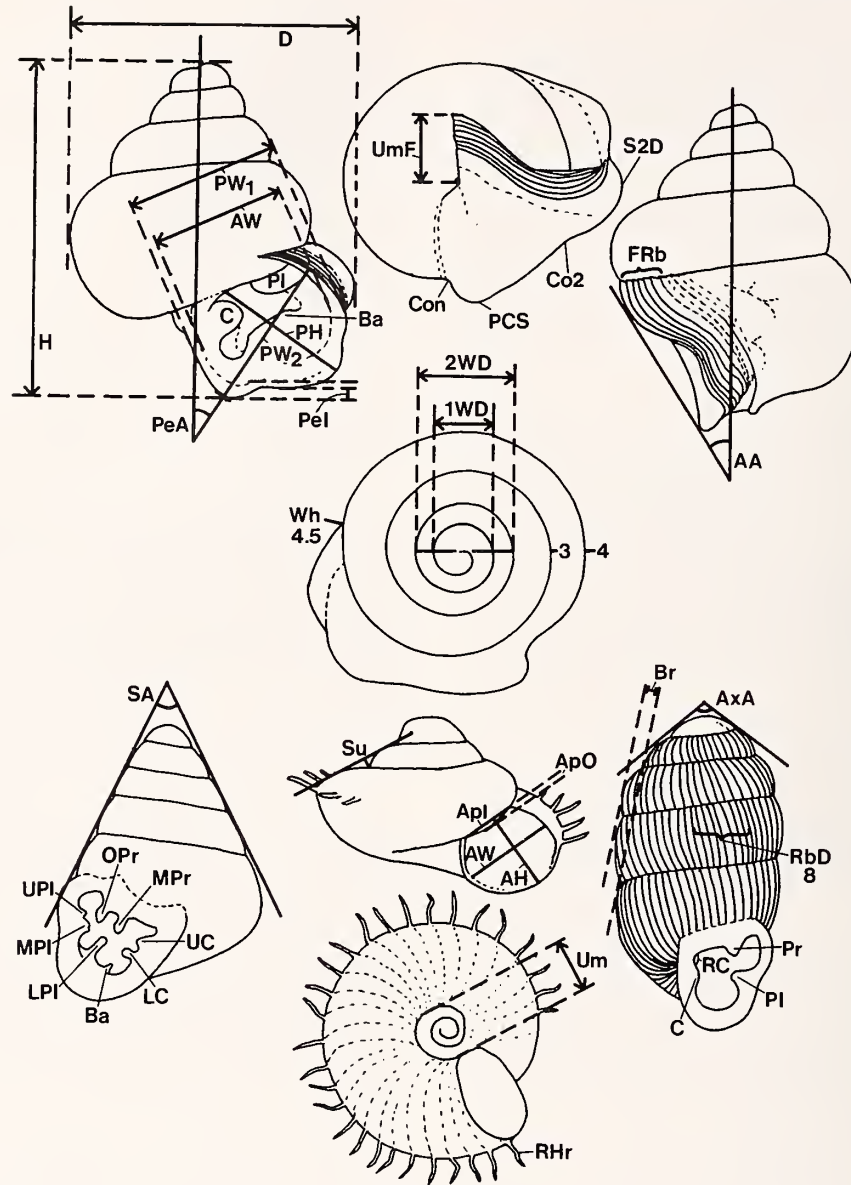


Figure 1

Some shell features measured, scored, and used in calculating descriptive characters. 1WD - first whorl diameter; 2WD - first two whorls diameter; AA - angle at which apertural plane is inclined from rotational axis; AH - aperture height (inside dimension measured to and perpendicular to a line between columellar and upper peristome insertions); Apl - distance between the columellar and upper peristome insertions; ApO - amount of aperture occupied by previous whorl; AW - aperture width (inside dimension measured parallel to a line between the columellar and upper peristome insertions); AxA - apex angle; Ba - basal denticle; Br - barreling (outward departure from a straight line of a tangent to the whorls between $n-0.5$ and about the second whorl); C - columellar denticle; Co2 - second body whorl constriction; Con - body whorl constriction; D - shell diameter; FRb - final ribs near body whorl aperture; H - shell height; LC - lower columellar denticle; LPI - lower palatal denticle; MPI - middle palatal denticle; MPr - middle parietal denticle; OPr - outer parietal denticle; PCS - post-constrictional body whorl swelling; PeA - angle from greatest width of aperture plus peristome to rotational axis; PeI - peristome baso-palatal indentation (expressed as percent of basal peristome width, i.e., to the unlabelled line above it in the figure); PH - aperture plus peristome greatest height as measured perpendicular to greatest width line; PI - palatal denticle; Pr - parietal denticle; PW1 - aperture plus peristome width (measured parallel to aperture width); PW2 - aperture plus peristome greatest width (measured on *Boucardicus* Fischer-Piette & Bedoucha, parallel to or within 40 degrees of parietal-callus line); RbD - transverse rib density (number in estimated tenth of whorl); RC - recessed columellar denticle; RHr - rib hairs; S2D - swelling after second body whorl constriction; SA - spire angle; Su - suture depth one half whorl from aperture; UC - upper columellar denticle; Um - umbilicus size before any change in body whorl growth direction; UmF - final umbilicus total size; UPI - upper palatal denticle; Wh - whorl number. From Emberton & Pearce (1999).

placed in the United States National Museum, Washington, D.C. (USNM); temporarily in the Molluscan Biodiversity Institute (MBI), whose collections will revert in the near future to the Florida Museum of Natural History; and in the Australian Museum, Sydney (AMS); the Muséum national d'Histoire naturelle, Paris (MNHN); and the Academy of Natural Sciences of Philadelphia (ANSP). For paratype localities, use the MBI catalog number to refer to the station numbers (in parentheses) above. MBI catalog numbers consist of station number, period, species number, D (dry) or A (alcohol-preserved), and when appropriate H (holotype) or P (paratype) or R (representative).

Class GASTROPODA

Clade HETEROBRANCHIA

Clade PULMONATA

Order STYLOMMATOPHORA

Suborder ORTHURETHRA

Superfamily CHONDRINOIDEA

Family ORCULIDAE

Genus *Fauxulus* Schaufuss, 1869

Fauxulus gaillardi

Fischer-Piette, Blanc, Blanc, & Salvat, 1994
(Figures 2, 26, 36)

Fauxulus sp. 1, Emberton et al., 1996:210. Emberton, 1997: 1148.

Representative: MBI 382.03DR, Tol-10 (ad).

Other specimens: MBI 382.03D (2 juv; AMS C.203437 [1 ad]), MBI 382.03A (1 ad), MBI 388.12A (1 ad [dissected]).

Description of representative shell:

Size and Shape. Shell sinistral. Diameter 3.7 mm; height 5.6 mm. Height-diameter ratio 1.5. Whorls 7.4. Spire angle 55 degrees. Apex angle 55 degrees. Spire profile convexity (outward departure from a straight line tangent to whorls n-0.5 and about the second whorl) 6% of shell diameter. Whorl periphery round. Suture depth one half whorl from aperture is 3% of shell diameter. Umbilicus before change in body whorl growth direction 3% of shell diameter. Final umbilicus 36% of shell diameter. Coiling tightness (whorl number divided by natural logarithm of shell diameter) 5.7.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 44% of shell diameter. Aperture height-width ratio (inside dimension, height measured to and perpendicular

to a line between the columellar and upper peristome insertions) 1.19. Distance between columellar and upper peristome insertions is 84% of aperture width. Penultimate whorl projecting into body whorl occupying 42% of aperture height measure. Columella not truncate. Columellar plica absent. Columella strongly reflected and flat. Apertural plane inclined downward 5 degrees from rotational axis. Aperture shape somewhat triangular. Peristome reflected; no second, internal peristome. Ratio of aperture width including peristome to aperture width excluding peristome 1.4. Change in growth direction of body whorl occurs 0.4 whorls behind aperture. Apertural dentition present, typical of *Fauxulus* (two parietal, two columellar, one basal, and three palatal denticles). Middle parietal denticle height 42% of aperture width. Outer parietal denticle height 35% of aperture width. Upper columellar denticle height 15% of aperture width. Lower columellar denticle height 15% of aperture width. Basal denticle height 7% of aperture width. Lower palatal denticle height 27% of aperture width. Middle palatal denticle form simple; height 11% of aperture width. Upper palatal denticle height 11% of aperture width.

Apex. First whorl diameter 0.7 mm. First two whorls diameter 1.1 mm. Embryonic whorls smooth.

Post-Embryonic Shell Sculpture and Color. Post-embryonic shell with crowded transverse ribs, about 15 in last tenth of body whorl; transverse ribs relatively straight above whorl periphery (angling forward down about 20 degrees), then at periphery, ribs bend abruptly back and inward (except not inward on the body whorl) then curve forward into the umbilicus; suture is a very short distance below the angled periphery, forming a canalicule. Basic shell color light yellow-brown. Peristome (excluding periostracum) white.

Description of lower reproductive system (MBI 388.12A: 1 adult): Penis 2.9 mm long, slender but apically bulbous. Penis without sheath or caecum. Penial retractor muscle attached just below midpoint of penis (1.3 mm above its juncture with the atrium). Epiphallus 4.1 mm long, proximally slender (same width as penis), swollen distally (to three times penis width) along two-fifths of its length. Vas deferens very slender along its entire length. Atrium small. Spermathecal duct and oviduct independently entering the atrium, thus vagina absent. Spermathecal duct wide (0.3 mm) and long (4.9 mm, including spermatheca), internally lamellar, adherent to oviduct.

Distribution: Known from Mts. Mahermana and Vasiha, 340 to 860 m elevation (this paper), and from another site in the Anosy chain at 1060 m elevation (Fischer-Piette et al., 1994).

Fauxulus andohahelae Emberton & Pearce, sp. nov.

(Figure 3)

Fauxulus sp. 2, Emberton et al., 1996:210. Emberton, 1997: 1148.



Figures 2–6

Figure 2. *Fauxulus gaillardi* Fischer-Piette, Blanc, Blanc & Salvat, 1994, Tol-10. Figure 3. *Fauxulus andohahelae* Emberton & Pearce, sp. nov., holotype. Figure 4. *Subulina mamillata* (Craven, 1880), Tol-12. Figure 5. *Curvella vohimena* Emberton & Pearce, sp. nov., holotype. Figure 6. *Opeas tsiveryi* Emberton & Pearce, sp. nov., holotype. All scale bars 1 mm.

Holotype: USNM 860792 (ex MBI 383.01DH, Tol-11, ad).

Paratypes: None.

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: southeast slope of Mount Vasiha, 700 m elevation: latitude 24°55'23"S, longitude 46°44'27"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Shell sinistral. Diameter 3.3 mm; height 4.4 mm. Height-diameter ratio 1.3. Whorls 5.8. Spire angle 55 degrees. Apex angle 55 degrees. Spire profile convexity (outward departure from a straight line tangent to whorls n-0.5 and about the second whorl) 1% of shell diameter. Whorl periphery flattened. Suture depth one half whorl from aperture is 1% of shell diameter. Umbilicus before change in body whorl growth direction 5% of shell diameter. Final umbilicus 36% of shell diameter. Coiling tightness (whorl number divided by natural logarithm of shell diameter) 4.9.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 42% of shell diameter. Aperture height-width ratio (inside dimension, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 1.09. Distance between columellar and upper peristome insertions is 73% of aperture width. Penultimate whorl projecting into body whorl occupying 38% of aperture height measure. Columella not truncate. Columellar plica absent. Columella strongly reflected and flat. Apertural plane inclined downward 10 degrees from rotational axis. Aperture shape somewhat triangular. Peristome reflected; no second, internal peristome. Ratio of aperture width including peristome to aperture width excluding peristome 1.4. Change in growth direction of body whorl occurs 0.4 whorls behind aperture. Apertural dentition present, typical of *Fauxulus* (two parietal, two columellar, one basal, and three palatal denticles). Middle parietal denticle height 25% of aperture width. Outer parietal denticle height 20% of aperture width. Upper columellar denticle height 9% of aperture width. Lower columellar denticle height 16% of aperture width. Basal denticle height 6% of aperture width. Lower palatal denticle height 25% of aperture width. Middle palatal denticle split into two closely spaced bumps; height 7% of aperture width. Upper palatal denticle height 5% of aperture width.

Apex. Embryonic whorls 1.7; diameter 0.4 mm. First whorl diameter 0.3 mm. First two whorls diameter 0.5 mm. Embryonic whorls smooth.

Post-Embryonic Shell Sculpture and Color. Post embryonic shell with crowded transverse ribs, about 15 in last tenth of body whorl; transverse ribs relatively straight above whorl periphery (angling forward down about 20 degrees), then at periphery, ribs bend abruptly back and

inward (except not inward on the body whorl) then curve forward into the umbilicus; suture is a very short distance below the angled periphery, forming a canalicule; transverse ribs crossed by a few poorly defined weak spiral lines. Basic shell color orange-tan. Peristome (excluding periostracum) red-orange and white.

Shell comparisons: Unique within the genus for its low spire, recessed lower palatal denticle, and nearly fused middle and upper palatal denticles.

Distribution: Known only from Mt. Vasiha at 700 m elevation.

Etymology: For the adjacent Andohahela Reserve. The type locality is expected to be incorporated into an eventual Andohahela National Park.

Suborder SIGMURETHRA

Infraorder ACHATINIDA

Superfamily ACHATINOIDEA

Family SUBULINIDAE

Genus *Subulina* Beck, 1837

Subulina mamillata (Craven, 1880)

(Figures 4, 27, 37)

Subulinidae sp. 1, Emberton et al., 1996:210. Emberton, 1997:1143, 1147, 1150, 1151.

Representative: MBI 386.01DR, Tol-14 (ad).

Other specimens: MBI 377.11D (1 ad, 1 juv), MBI 378.13D (2 ad), MBI 379.15D (2 ad, 4 juv), MBI 379.15A (1 juv), MBI 380.12D (2 juv), MBI 381.09D (4 ad, 2 juv), MBI 382.12D (2 juv), MBI 383.09D (1 juv), MBI 384.11D (7 ad, 15 juv), MBI 384.11A (1 ad, 2 juv), MBI 385.06D (21 ad, 30 juv), MBI 385.06A (1 ad, 2 juv), MBI 386.01D (17 ad, 52 juv; AMS C.203438 [1 ad]; MNHN [1 ad]; ANSP 400829 [1 ad]), MBI 386.01A (4 ad [2 dissected], 3 juv), MBI 387.06D (1 ad, 1 juv), MBI 388.04D (1 ad).

Description of representative shell:

Shell Size and Shape. Shell dextral. Diameter 4.1 mm; height 20.2 mm. Height-diameter ratio 5.0. Whorls 11.0. Spire angle 10 degrees. Apex angle 15 degrees. Spire profile convexity (outward departure from a straight line tangent to whorls n-0.5 and about the second whorl) 8% of shell diameter. Whorl periphery slightly flattened. Suture depth one half whorl from aperture is 5% of shell diameter. Final umbilicus 0% of shell diameter. Coiling tightness (whorl number divided by natural logarithm of shell diameter) 7.8.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome inser-

tions) 65% of shell diameter. Aperture height-width ratio (inside dimension, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.85. Distance between columellar and upper peristome insertions is 88% of aperture width. Penultimate whorl projecting into body whorl occupying 6% of aperture height measure. Columella truncate. Columellar plica absent. Columella not reflected. Apertural plane inclined downward; 15 degrees from rotational axis. Aperture shape ovate. Peristome simple; no second, internal peristome. No change in growth direction of body whorl near aperture. Apertural dentition absent.

Apex. First whorl diameter 0.7 mm. First two whorls diameter 1.1 mm. Embryonic whorls eroded.

Post-Embryonic Shell Sculpture and Color. Post embryonic shell with weak irregular growth ridges. Basic shell color yellow-tan.

Shell variation: Occasional shells are more tightly coiled, with a more slender appearance, than the illustrated representative.

Shell comparisons: Whorls more flattened, sutures less crenulate, and slightly more slender than the introduced *Subulina octona* (Chemnitz). Body whorl occupying a greater proportion of the shell height than *S. manampetsaensis* Fischer-Piette & Testud, as illustrated by Fischer-Piette et al. (1994:33).

Description of lower reproductive system (MBI 386.01A: 2 adults): Penis 2.7 mm long, seemingly in two sections: base 1.8 mm long, slender and thin walled, apically swollen about a tongue-shaped verge that is rolled into a conical shape 0.5 mm long and, apically, 0.3 mm wide; penis apex (epiphallus?) 0.9 mm long, 0.1 mm wide basally, curved, swollen at the tip, with complex undetermined internal structure. Penis lacks caecum and seems to lack sheath. Wall of basal penis smooth, without pilasters or hooks of any size. Penial retractor muscle attached at the penial apex. Epiphallus seemingly absent. Vas deferens slender along its entire length. Atrium small. Spermathecal duct joining oviduct 1.5 mm above the atrium, hence vagina 1.5 mm long. Spermatheca and its duct 1.5 mm long, adherent to oviduct. Egg in oviduct 2.0 × 1.4 mm.

Distribution: Mts. Ilapiry and Vasiha from 100 to 700 m elevation (this paper), and from Rhodesia, the Transvaal, and widespread in Madagascar (Fischer-Piette et al., 1994).

Comments: This species, probably introduced, seems to be an indicator of ecological degradation (Emberton, 1997).

Genus *Curvella* Chaper, 1885

Curvella vohimena Emberton & Pearce, sp. nov.

(Figure 5)

Subulinidae sp. 2, Emberton et al., 1996:210. Emberton, 1997:1148.

Holotype: USNM 860793 (ex MBI 376.03DH, Tol-4, ad).

Paratypes: MBI 379.16DP (1 juv; AMS C.203439 [1 ad]), MBI 380.26AP (1 ad), MBI 381.10D (1 ad, 2 juv), MBI 391.05AP (1 ad).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: northeast of village of Esetra: valley on northwest slope of Mt. Mahermana, elevation 100 m: 24°26'22"S, 47°12'41"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Shell dextral. Diameter 1.8 mm; height 3.9 mm. Height-diameter ratio 2.1. Whorls 4.8. Spire angle 30 degrees. Apex angle 35 degrees. Spire profile convexity (outward departure from a straight line tangent to whorls n-0.5 and about the second whorl) 2% of shell diameter. Whorl periphery round. Suture depth one half whorl from aperture is 7% of shell diameter. Final umbilicus 0% of shell diameter. Coiling tightness (whorl number divided by natural logarithm of shell diameter) 8.2.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 59% of shell diameter. Aperture height-width ratio (inside dimension, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.89. Distance between columellar and upper peristome insertions is 70% of aperture width. Penultimate whorl projecting into body whorl occupying 2% of aperture height measure. Columella not truncate. Columellar plica absent. Columella slightly reflected. Apertural plane inclined downward 5 degrees from rotational axis. Aperture shape ovate. Peristome simple; no second, internal peristome. No change in growth direction of body whorl near aperture. Apertural dentition absent.

Apex. Embryonic whorls 1.6; diameter 0.7 mm. First whorl diameter 0.6 mm. First two whorls diameter 0.8 mm. Embryonic whorls with very weak spiral ridges plus sub-sutural crenulations.

Post-Embryonic Shell Sculpture and Color. Post-embryonic shell with irregular growth ridges. Basic shell color pale yellow-tan.

Shell variation: No conspicuous variation in size or shape.

Shell comparisons: Much smaller with fewer whorls than *Curvella (?) poutiersi* Fischer-Piette, Blanc, Blanc &

Salvat, 1994; upper edge of aperture angled upward less steeply so aperture is less high for its width.

Distribution: Known only from the Vohimena-Chain Mts. Mahermana and Ilapiry, 100 to 400 m elevation.

Comments: Assigned to *Curvella* because the upper apertural edge curves backward at the upper suture.

Etymology: For the Vohimena Mountain Chain, north of Fort Dauphin.

Genus *Opeas* Albers, 1850

Opeas tsiveryi Emberton & Pearce, sp. nov.

(Figures 6, 38)

Subulinidae sp. 3, Emberton et al., 1996:210. Emberton, 1997:1147, 1150.

Holotype: USNM 860794 (ex MBI 387.02DH, Tol-15, ad).

Paratypes: MBI 385.07DP (1 ad), MBI 386.09DP (1 ad, 1 juv), MBI 387.02DP (2 ad, 2 juv; AMS C.203440 [1 ad]; MNHN [1 ad]; ANSP 400830 [1 ad]), MBI 387.02AP (3 ad [1 dissected]).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: eastsoutheast slope of Mount Vasiha, 200 m: 24°56'13"S, 46°45'13"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Shell dextral. Diameter 1.8 mm; height 4.3 mm. Height-diameter ratio 2.4. Whorls 5.7. Spire angle 25 degrees. Apex angle 35 degrees. Spire profile convexity (outward departure from a straight line tangent to whorls n-0.5 and about the second whorl) 5% of shell diameter. Whorl periphery slightly flattened. Suture depth one half whorl from aperture is 6% of shell diameter. Final umbilicus 10% of shell diameter. Coiling tightness (whorl number divided by natural logarithm of shell diameter) 9.7.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 59% of shell diameter. Aperture height-width ratio (inside dimension, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.92. Distance between columellar and upper peristome insertions is 77% of aperture width. Penultimate whorl projecting into body whorl occupying 8% of aperture height measure. Columella not truncate. Columellar plica absent. Columella slightly reflected. Apertural plane inclined downward 5 degrees from rotational axis. Aperture shape ovate. Peristome simple; no second, internal peristome. No change in growth direction of body whorl near aperture. Apertural dentition absent.

Apex. First whorl diameter 0.5 mm. First two whorls

diameter 0.8 mm. Embryonic whorls smooth then with transverse ribs.

Post-Embryonic Shell Sculpture and Color. Post-embryonic shell with strong, irregular transverse growth ridges, curved backward moderately strongly at upper suture. Basic shell color pale yellow-white.

Shell variation: No conspicuous variation in size or shape.

Shell comparisons: Similar in shape to *Opeas soulaianus* Fischer-Piette & Testud but the translation rate is slower, leading to squatter individual whorls and more deeply impressed sutures; the adult height (4.5 mm) and number of whorls (5.5) are considerably less (10 mm and 9 whorls, respectively, in *Opeas soulaianus*).

Description of lower reproductive system (MBI 387.02AP: 1 adult):

Penis morphology unknown. Spermathecal duct joining oviduct 0.3 mm above the atrium, hence vagina 0.3 mm long. Spermatheca and its duct 0.4 mm long.

Distribution: Known only from Mt. Vasiha, from 100 to 400 m elevation.

Comments: A live-collected paratype similar in size to the holotype contained eggs, suggesting that this species is not simply a juvenile of the larger *Opeas soulaianus* Fischer-Piette & Testud, 1973. Further study is needed to determine whether this species is within the range of variation of *O. soulaianus*.

Etymology: For our guide Tsivery (his name means "never lost") of Malio, who bravely continued to collect snails on Mt. Vasiha after suffering a scorpion sting.

Superfamily STREPTAXOIDEA

Family STREPTAXIDAE

Genus *Streptostele* Dohrn, 1866

Subgenus *Streptostele* (*Makrokonche*) Emberton, 1994

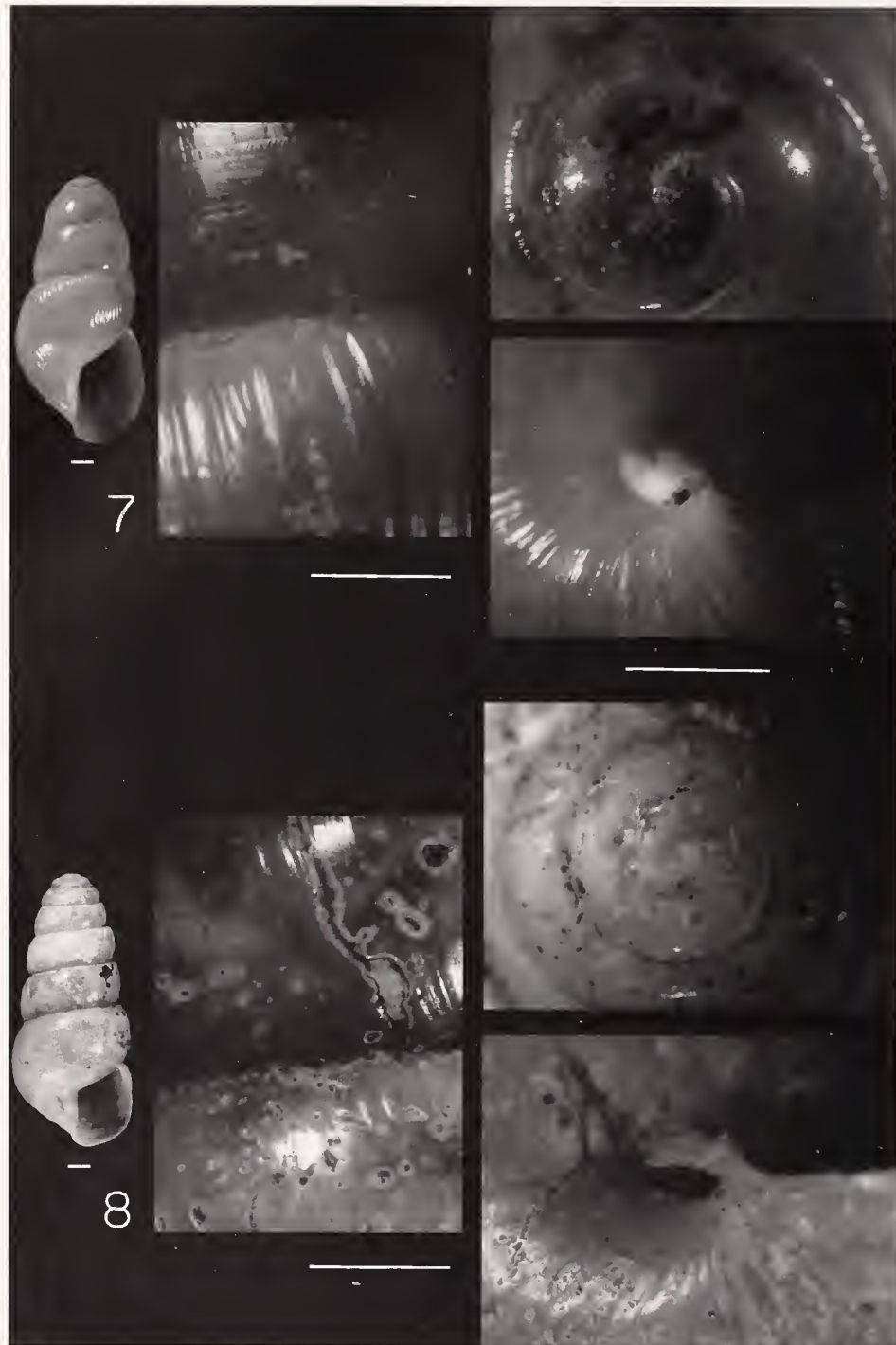
Streptostele (*Makrokonche*) *magnapex* Emberton & Pearce, sp. nov.

(Figure 7)

Streptaxidae sp. 1, Emberton et al., 1996:210. Emberton, 1997:1147. Emberton et al., 1999:table 2.

Holotype: USNM 860795 (ex MBI 373.05DH, Tol-1, juv).

Paratypes: MBI 374.13DP (1 juv), MBI 375.11DP (1 juv), MBI 377.12DP (1 juv), 378.14DP (1 juv), MBI 379.17DP (1 juv; AMS C.203441 [1 juv]), MBI



Figures 7-8

Figure 7 (four views). *Streptosteles (Makrokonche) magnapex* Emberton & Pearce, sp. nov., holotype. Figure 8 (four views). *Streptosteles (Makrokonche) vohimenensis* Emberton & Pearce, sp. nov., holotype. All scale bars 1 mm.

379.17AP (1 juv), MBI 382.13DP (1 juv), MBI 385.08DP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: northeast of village of Esetra: summit of Mt. Mahermana, 340 m: 24°26'12"S, 47°13'13"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 5.8 mm; height 11.7 mm. Height-diameter ratio 2.0. Whorls 4.7. Coiling tightness (whorl number divided by natural logarithm of shell height) 1.9. Apex angle 130 degrees. Spire angle 30 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 4.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 2.0 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 1.6. Apical sculpture smooth.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 67% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 67% of aperture width. Penultimate whorl projecting into body whorl; occupying 6% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella strongly reflected and rolled.

Shell Sculpture. Transverse rib density 8 in the seventh or eighth tenth of body whorl; rib height 0.01% of shell diameter. Strength of rib sculpture completely diminished toward apex. Suture simple. Sutural notch density same as that of transverse ribs. Sculpture besides transverse ribs consists of evenly spaced spiral grooves, numbering 15 between sutures.

Shell comparisons: Unique for its size, shape, and spiral-groove sculpture. Calls to mind a juvenile *Streptostele manumbensis* Emberton, 1994, but is about twice as large. Bears a superficial resemblance to a juvenile of the acavid *Clavator obtusatus* (Gmelin, 1791).

Distribution and conservation status: Mts. Mahermana, Ilapiry and Vasiha, known from 200 to 860 m elevation. Also reported (Emberton, in press) from Pic St. Louis, 500–530 m. Thus apparently restricted to fragmented forest patches within the Vohimena Chain and the southern Anosy Chain, within < 1000 km² of forest that is continually declining in extent and in quality of habitat. Under IUCN (1996) criteria, this is an Endangered species.

Comments: All specimens are juveniles. The adult could be the largest streptaxid known from Madagascar.

Etymology: For the large (*L. magni*) apical whorls (*L. apex*).

Streptostele (Makrokonche) vohimenensis
Emberton & Pearce, sp. nov.

(Figure 8)

Streptaxidae sp. 2, Emberton et al., 1996:210. Emberton, 1997:1147, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860796 (ex MBI 375.02DH, Tol-3, juv).

Paratypes: MBI 373.25AP (1 juv), MBI 374.14DP (2 juv; AMS C.203442 [1 juv]), MBI 374.14AP (1 juv), MBI 375.02DP (1 juv; MHNH [1 juv]), MBI 379.18DP (1 juv), MBI 379.18AP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: northeast of village of Esetra: west slope of Mt. Mahermana, 200 m: 24°26'15"S, 47°13'04"E primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 5.3 mm; height 12.0 mm. Height-diameter ratio 2.3. Whorls 7.8. Coiling tightness (whorl number divided by natural logarithm of shell height) 3.1. Apex angle 135 degrees. Spire angle 25 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 6.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.8 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 0.9. Apical sculpture smooth.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 51% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 74% of aperture width. Penultimate whorl projecting into body whorl; occupying 7% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 10 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture completely diminished toward apex. Suture canaliculate. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: More tightly coiled than *Streptostele manumbensis* Emberton, 1994. Weaker sculpture and proportionately larger aperture than *Parvedentulina metula* (Crosse).

Distribution and conservation status: Mts. Mahermana and Ilapiry, 200 to 400 m elevation. Also found on Pics St. Louis and St. Jacques, southern Vohimena Chain; and, apparently, also on Mt. Sangasanga (430 m; 21°22'20"S,

47°52'05"E), near Kianjavato (Emberton, in press). Thus the known range of this species is in lowland rainforest from southwest of Mananjary, south to near Fort Dauphin, an area of fragmented and rapidly disappearing forest much less than 5000 km². Under IUCN (1996) criteria, *Streptostele volhimenensis* sp. nov. is Endangered.

Etymology: For the Vohimena Mountain chain north of Ft. Dauphin.

Streptostele (Makrokonche) bougieformis

Emberton & Pearce, sp. nov.

(Figures 9, 10)

Streptaxidae sp. 3, Emberton et al., 1996:210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860797 (ex MBI 384.02DH, Tol-12, juv).

Paratypes: MBI 382.14DP (2 juv), MBI 383.16AP (1 juv), MBI 384.02DP (2 juv; AMS C.203443 [1 juv]), MBI 384.02AP (1 juv), MBI 385.09DP (1 juv), MBI 387.07DP (2 juv), MBI 387.07AP (1 juv), MBI 388.05DP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: east slope of Mt. Vasiha, 500 m: 24°55'19"S, 46°44'45"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 6.1 mm; height 16.1 mm. Height-diameter ratio 2.6. Whorls 8.9. Coiling tightness (whorl number divided by natural logarithm of shell height) 3.2. Apex angle 140 degrees. Spire angle 20 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 3.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.9 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 0.8.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 55% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.8. Distance between columellar and upper peristome insertions is 78% of aperture width. Penultimate whorl projecting into body whorl; occupying 4% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent.

Shell Sculpture. Transverse rib density 9 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture canaliculate. Sutural notch density

same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: More tightly coiled, more slender, and with a much greater constriction of the spire than *Streptostele manumbensis*. Also, the baso-columellar edge of the aperture is angular, as opposed to round. One-and-a-half times as high for the same number of whorls as *Parvedentulina simeni* (Fischer-Piette, Blanc, Blanc, & Salvat comb. nov.), but similar in shape.

Distribution and conservation status: Known only from Mt. Vasiha, from 100 to 860 m elevation. Not found anywhere else (Emberton, in press). A Critically Endangered species, because known from only one locality, with an extent of occurrence < 100 km², and with its habitat continually declining in area and quality (IUCN, 1996).

Etymology: For its similarity in form (*L. formis*) to a candle (French *bougie*).

Streptostele (Makrokonche) latapex Emberton & Pearce, sp. nov.

(Figures 11, 28, 32, 39, 40)

Streptaxidae sp. 4, Emberton et al., 1996:210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860798 (ex MBI 382.04DH, Tol-10, juv).

Paratypes: MBI 377.13DP (1 juv), MBI 381.11DP (9 juv), MBI 381.11AP (1 juv), MBI 382.04DP (14 juv; AMS C.203444 [1 juv]; MNHN [1 juv]; ANSP 400831 [1 juv]), MBI 382.04AP (1 juv), MBI 384.12DP (1 juv), 387.13AP (1 ad [dissected], 1 juv).

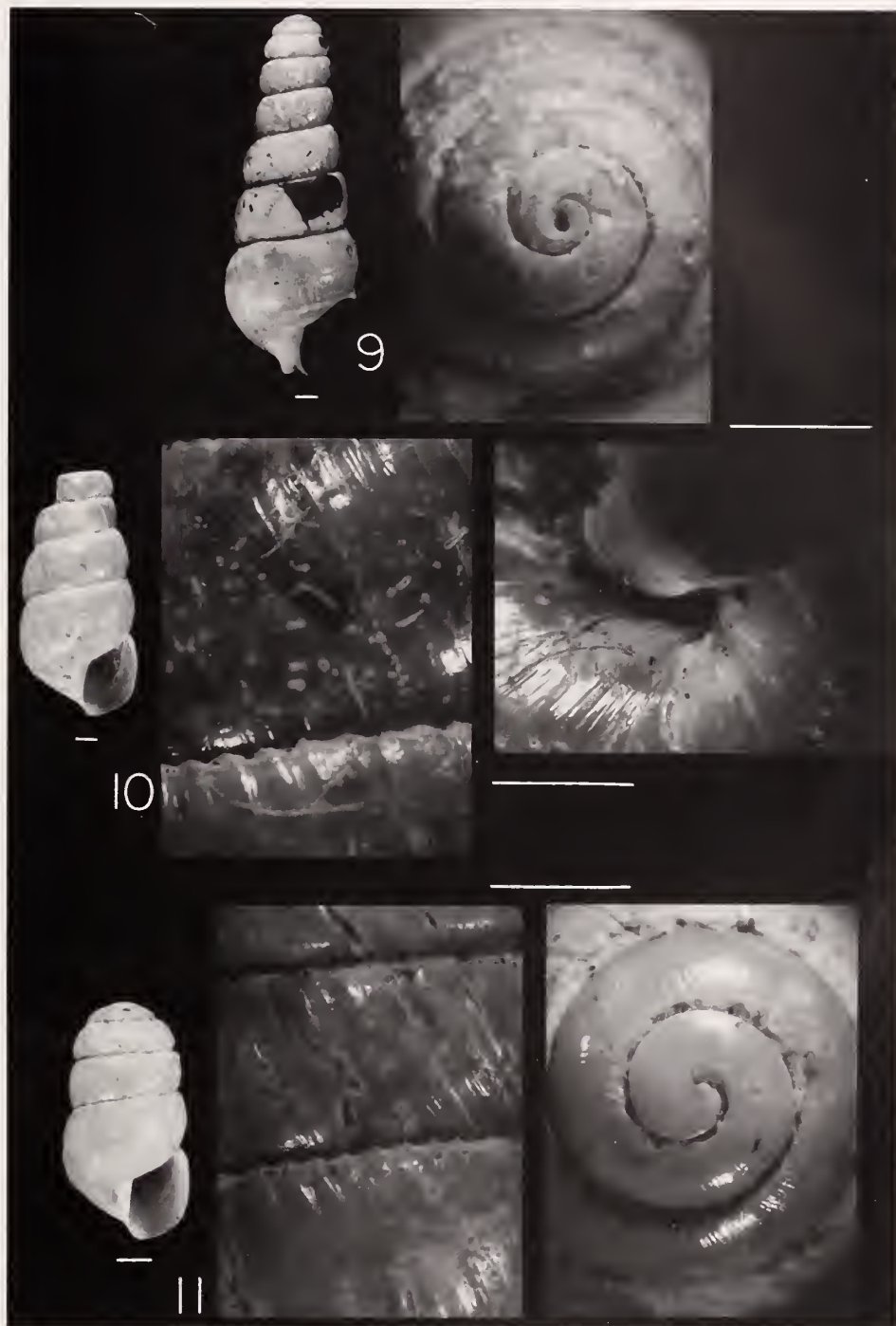
Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: lower summit of Mt. Vasiha, 860 m: 24°55'18"S, 46°44'19"E.: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 3.6 mm; height 6.7 mm. Height-diameter ratio 1.9. Whorls 5.6. Coiling tightness (whorl number divided by natural logarithm of shell height) 2.9. Apex angle 150 degrees. Spire angle 25 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 6.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 1.2 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 0.9. Apical sculpture faint, complete transverse striae after first 1.1 smooth whorls.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 58% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome inser-



Figures 9–11

Figures 9–10. *Streptosteles (Makrokonche) bougieformis* Emberton & Pearce, sp. nov.: holotype (Figure 9, two views) and paratype (Figure 10, three views). Figure 11. *Streptosteles (Makrokonche) latapex* Emberton & Pearce, sp. nov., holotype. All scale bars 1 mm.

tions) 0.9. Distance between columellar and upper peristome insertions is 67% of aperture width. Penultimate whorl projecting into body whorl; occupying 6% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent.

Shell Sculpture. Transverse rib density 7 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture shouldered. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: Unique for its broadly domed apex and huge initial whorl.

Description of lower reproductive system (MBI 387.13AP: 1 adult): Penis 2.7 mm long, 0.4–0.5 mm wide. Penial sheath present, 0.4 mm high, incorporating loop of vas deferens. Penial apical caecum absent. Penial general sculpture without pilasters, with an even field of medium-sized hooks, and without giant apical and basal hooks. Penial retractor muscle attached at the penial apex. Epiphallus absent. Vas deferens slender along its entire length. Atrium medium in size. Spermathecal duct joining oviduct 1.0 mm above the atrium, hence vagina 1.0 mm long. Spermathecal duct slender, at least 5 mm long, partially adherent to oviduct. Embryonic shells in oviduct 2.2 whorls.

Distribution and conservation status: Mts. Ilapiry and Vasiha, known from 200 to 860 m elevation. Not found anywhere else (Emberton, in press). Under IUCN (1996) criteria, an Endangered species, restricted to fragmented subpopulations within < 1000 km² of declining forest.

Etymology: For the wide (L. *lat-*) apex (L. *apex*).

Streptostele (Makrokonche) latembryohelix

Emberton & Pearce, sp. nov.

(Figure 12)

Streptaxidae sp. 5, Emberton et al., 1996:210. Emberton, 1997:1147. Emberton et al., 1999:table 2.

Holotype: USNM 860799 (ex MBI 381.04DH, Tol-9, juv).

Paratypes: MBI 379.19DP (1 juv), MBI 381.04DP (0; AMS C.203445 [1 juv]).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Mahialambo: east-southeast slope of Mt. Ilapiry, 200 m: 24°51'39"S, 47°00'46"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 5.0 mm; height 8.4 mm. Height-diameter ratio 1.7. Whorls 6.4. Coiling tightness (whorl number divided by natural logarithm of shell height) 3.0. Apex angle 155 degrees. Spire angle 35 de-

grees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 6.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 1.0 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 1.0. Apical sculpture strong, incomplete (sutural) transverse striae after first 1.3 smooth whorls.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 48% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 77% of aperture width. Penultimate whorl projecting into body whorl; occupying 4% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella strongly reflected and flat.

Shell Sculpture. Transverse rib density 9 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture shouldered. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: Unique for its beehive shape and big initial whorl.

Distribution and conservation status: Known only from Mt. Ilapiry, from only 200 to 400 m elevation. No report of any other localities (Emberton, in press). A Critically Endangered species: a single locality, declining habitat, extent < 100 km² (IUCN, 1996).

Etymology: For the broad (L. *lati*) embryonic whorl (L. *helix*).

Genus *Parvedentulina* gen. nov.

Parvedentulina Emberton & Pearce, gen. nov.

Edentulina (?) Pfeiffer, 1856, Fischer-Piette et al., 1994:58–62, figs. 39–43.

Type species: *P. ovatostoma* sp. nov.

Other species: *P. acutapex* sp. nov.; *P. apicostriata* sp. nov.; *P. esetra* sp. nov.; *P. glessi* (Fischer-Piette, Blanc, Blanc, & Salvat, 1994) comb. nov.; *P. latembryohelix* sp. nov.; *P. mahialamboensis* sp. nov.; *P. margostriata* sp. nov.; *P. metula* (Crosse, 1881) comb. nov.; *P. rogeri* sp. nov.; and *P. simeni* (Fischer-Piette, Blanc, Blanc, & Salvat, 1994) comb. nov.

Description of shell:

Shell Size and Shape. Diameter 1.6–4.0 mm; height 3.6–11.0 mm. Height-diameter ratio 2.1–2.8. Whorls 5.9–7.5. Coiling tightness (whorl number divided by natural



Figures 12–15

Figure 12 (three views). *Parvedentulina latembryohelix* Emberton & Pearce, sp. nov., holotype. Figure 13. (four views) *Parvedentulina rogeri* Emberton & Pearce, sp. nov., holotype (tall shell and right apex) and paratype Tol-9 (short shell and left apex). Figure 14. *Gulella benjamini* Emberton & Pearce, sp. nov., holotype. Figure 15. *Gulella recae* Emberton & Pearce, sp. nov., holotype. All scale bars 1 mm.

logarithm of shell height) 3.5–4.8. Apex angle 100–150 degrees. Spire angle 15–25 degrees. Barreling (outward departure from a straight line of the whorls between $n-0.5$ and about the second whorl) 7–10% of shell diameter. Umbilicus minute.

Apex. First whorl diameter approximately 0.5–0.7 mm. Apical sculpture smooth; or faint, minute spiral striae; or faint to strong, complete or incomplete (sutural) transverse striae after the first 0.7–1.2 smooth whorl.

Aperture. Aperture ovate in shape; width (inside dimension, parallel to a line between the columellar and upper peristome insertions) approximately 0.4 shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.8–1.0. Distance between columellar and upper peristome insertions is 0.7–0.9 aperture width. Penultimate whorl projecting into body whorl; occupying 4–10% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Outer lip unreflected. Columella reflection slight to strong and flat.

Shell Sculpture. Transverse rib density 9–20 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture either not diminished or half diminished toward apex. Suture simple or shouldered. Sutural notch density either the same as or two-thirds the density of the transverse ribs. Besides transverse ribs, there may be faint spiral grooves below the whorl periphery.

Description of lower reproductive system: Penis 0.5–0.7 shell diameter. Penial sheath present, enclosing one-fifth to three-fourths of the length of the penis, and incorporating a loop of the vas deferens. Penial apical caecum absent. Penial general sculpture without pilasters, with an even field of medium-sized hooks, and with one giant apical hook and one giant basal hook, each arising from a large papilla. Penial retractor muscle attached at the penial apex or just above it on the vas deferens. Epiphallus absent. Vas deferens equally slender along its entire length or moderately wider alongside the penis. Atrium small to medium in size. Spermathecal duct joining oviduct approx. 0.2 mm above the atrium, hence vagina approx. 0.2 mm long. Spermathecal duct slender and long; or broad, short, and undifferentiated from the spermathecal sac. Ovoviviparous; embryonic shell(s) in oviduct with 2.2 whorls.

Comparisons:

Shell. Differs from small *Streptostele* Dohrn, 1866 (*sensu* Pilsbry, 1919) in its conspicuously more domed and more bluntly apexed shell (compare Figures 16–24 [this paper] with Pilsbry's [1919] plate XXI). Differs from *Streptostele* (*Makrokonche*) Emberton, 1994, in its much smaller adult size and slightly more domed shape. Differs from *Edentulina* Pfeiffer, 1856, in its much smaller size, greater delicacy, and unreflected outer lip. Differs

from edentate *Gulella* in its taller, more capacious aperture, and less domed shell. Resembles no other known genera of Streptaxidae (Zilch, 1959–1960; Richardson, 1988).

Reproductive Anatomy. Differs from all other known streptaxids in its gigantic basal and apical penial hooks.

Comments: *Streptostele* (*Makrokonche*), because of its conchological similarities in most features except size, and genitalic similarity in all but giant penial hooks, may eventually need to be transferred to *Parvedentulina* gen. nov. or elevated to genus. Streptaxid relationships are poorly understood; any such revision should be based on synapomorphies rather than similarities.

Etymology: For its partial resemblance to a small (*L. parvi-*) *Edentulina* Pfeiffer, 1856.

Gender: feminine.

Parvedentulina rogeri sp. nov.

(Figures 13, 29, 33, 41, 42)

Streptaxidae sp. 6, Emberton et al., 1996:210. Emberton, 1997:1143, 1146, 1149, 1151. Emberton et al., in press: table 2.

Holotype: USNM 860800 (ex MBI 386.02DH, Tol-14, ad).

Paratypes: MBI 378.22AP (1 juv), MBI 384.13DP (1 juv), MBI 385.10DP (2 ad, 1 juv), MBI 385.10AP (2 juv), MBI 386.02DP (9 ad, 44 juv; AMS C.203446 [1 ad]; MNHN [1 ad]; ANSP 400832 [1 ad]), MBI 386.02AP (3 ad [1 dissected], 12 juv), MBI 387.08DP (14 ad, 38 juv), MBI 387.08AP (4 ad, 16 juv), MBI 388.06DP (2 ad, 17 juv), MBI 388.06AP (1 ad, 8 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: southsoutheast slope of Mt. Vasiha, 300 m: 24°55'37"S, 46°44'49"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 3.0 mm; height 6.4 mm. Height-diameter ratio 2.2. Whorls 7.0. Coiling tightness (whorl number divided by natural logarithm of shell height) 3.8. Apex angle 150 degrees. Spire angle 25 degrees. Barreling (outward departure from a straight line of the whorls between $n-0.5$ and about the second whorl) 10.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.7 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 1.6. Apical sculpture strong, incomplete (sutural) transverse striae after first 1.0 smooth whorl.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 49% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a

line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 74% of aperture width. Penultimate whorl projecting into body whorl; occupying 5% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella strongly reflected and flat.

Shell Sculpture. Transverse rib density 9 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture shouldered. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell variation: There is considerable variation in the size of the first whorl, as demonstrated in Figure 13. There is also some variation in post-embryonic coiling tightness, resulting in some shells appearing more slender (Figure 13).

Shell comparisons: Similar in shape to *Parvedentulina metula*, but less than two-thirds as large for the same number of whorls.

Description of lower reproductive system (MBI 386.02AP: 1 adult): Penis 2.1 mm long, 0.2–0.3 mm wide. Penial sheath present, 0.4 mm high, incorporating loop of vas deferens. Penial apical caecum absent. Penial general sculpture without pilasters, with an even field of medium-sized hooks, and with one giant apical hook and one giant basal hook, each arising from a large papilla. Penial retractor muscle attached at the penial apex. Epiphallus absent. Vas deferens slender along its entire length. Atrium medium in size. Spermathecal duct joining oviduct 0.2 mm above the atrium, hence vagina 0.2 mm long. Spermathecal duct slender, at least 5 mm long, partially adherent to oviduct. Embryonic shells in oviduct 2.2 whorls.

Distribution and conservation status: Mts. Ilapiry and Vasiha, 100 to 500 m elevation. No other localities known (Emberton, in press). Thus apparently restricted to lower elevations of the southern Vohimena and Anosy Chains. An Endangered species: fragmented subpopulations with a continually diminishing extent of forest < 1000 km².

Etymology: For Roger Randalana, collector extraordinaire, of Ambatolahy, near Ranomafana National Park.

Parvedentulina acutapex Emberton & Pearce, sp. nov.

(Figures 16, 30, 47)

Streptaxidae sp. 9, Emberton et al., 1996:209, 210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860801 (ex MBI 387.03DH, Tol-15, ad).

Paratypes: MBI 385.11DP (4 ad, 8 juv; AMS C.203449

[1 ad]; MNHN [1 ad]; ANSP 400834 [1 ad]), MBI 385.11AP (3 ad [1 dissected], 2 juv), MBI 386.10DP (1 juv), MBI 387.03DP (6 ad, 3 juv), MBI 387.03AP (5 ad, 2 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: eastsoutheast slope of Mt. Vasiha, 200 m: 24°56'13"S, 46°45'13"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 1.6 mm; height 3.9 mm. Height-diameter ratio 2.5. Whorls 6.0. Coiling tightness (whorl number divided by natural logarithm of shell height) 4.4. Apex angle 100 degrees. Spire angle 20 degrees. Barrelling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 8.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.6 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 6.5. Apical sculpture faint, complete transverse striae after first 1.1 smooth whorls.

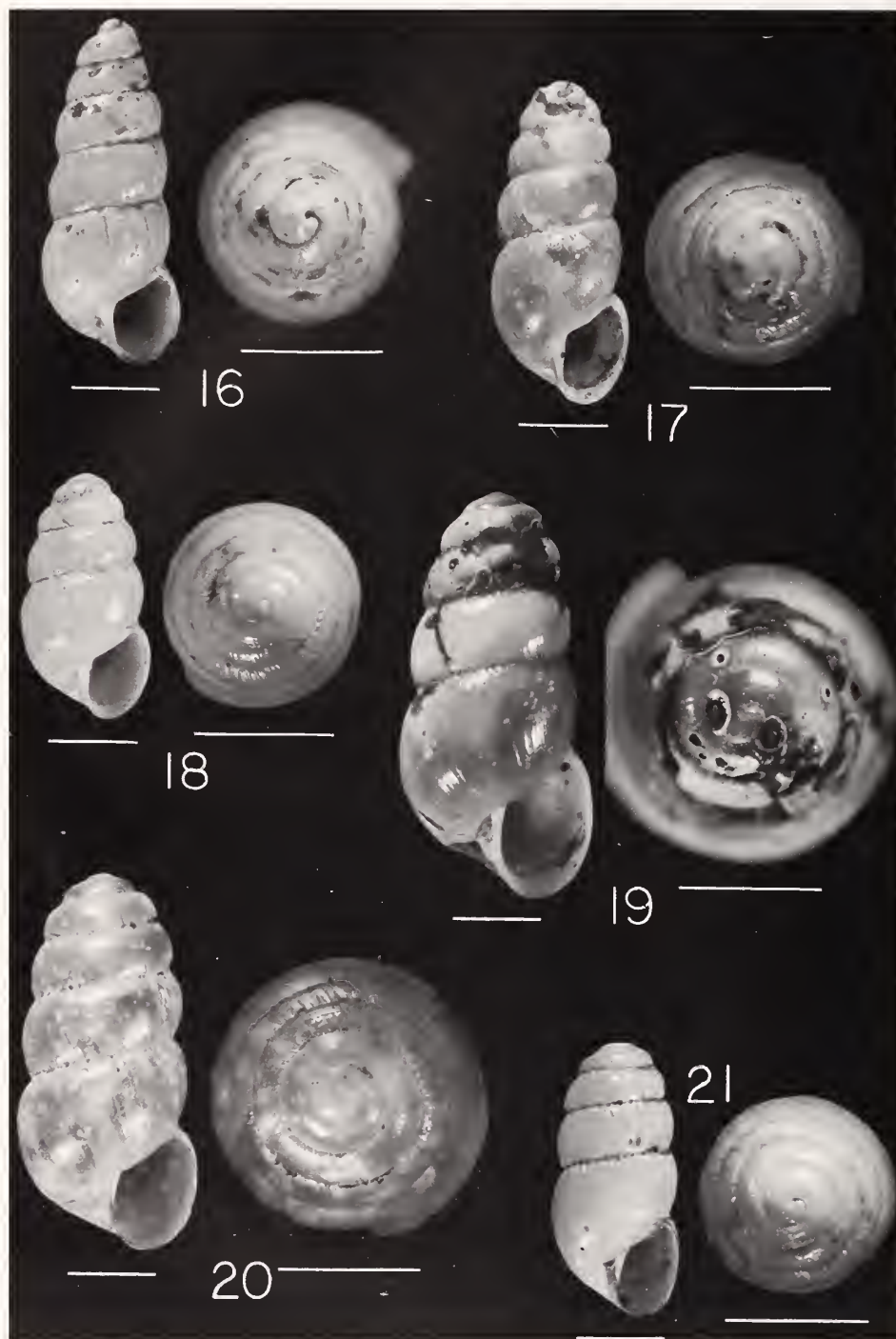
Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 51% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 1.0. Distance between columellar and upper peristome insertions is 75% of aperture width. Penultimate whorl projecting into body whorl; occupying 10% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 8 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture simple. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell variation: No conspicuous variation in size or shape.

Shell comparisons: Unique in its acutely skewed initial whorl.

Description of lower reproductive system (MBI 385.11AP: 1 adult): Penis 0.8 mm long, 0.1 mm wide, swollen at apex. Penial sheath present, 0.6 mm high, covering three-fourths of the length of the penis, and incorporating a loop of the vas deferens. Penial apical caecum absent. Penial general sculpture unknown, but apparently without pilasters. Penial retractor muscle attached just above the penial apex on the vas deferens. Epiphallus seemingly absent. Vas deferens slender from the prostate to the sheath, swollen from the sheath to the penis. Atrium small in size. Spermathecal duct joining the oviduct



Figures 16-21

Figure 16. *Parvedentulina acutapex* Emberton & Pearce, sp. nov., holotype. Figures 17, 18. *Parvedentulina margostriata* Emberton & Pearce, sp. nov.: holotype (Figure 17) and paratype, Tol-3 (Figure 18). Figure 19. *Parvedentulina esetra* Emberton & Pearce, sp. nov., holotype. Figure 20. *Parvedentulina apicostriata* Emberton & Pearce, sp. nov., holotype. Figure 21. *Parvedentulina ovastoma* Emberton & Pearce, sp. nov., paratype, Tol-11. All scale bars 1 mm.

0.2 mm above the atrium, hence the vagina is 0.2 mm in length. Spermatheca and duct conspicuously broad (0.1 mm) and short (0.5 mm), curved, with internal, longitudinal lamellar sculpture, the spermatheca not clearly demarcated from its duct.

Comments: The aberrant shell apex, spermatheca, penial sheath, and penial-retractor-muscle attachment suggest this may be a different (and new) genus. Penial sculpture remains unknown.

Distribution and conservation status: Mt. Vasiha, 200 to 400 m elevation. Also reported from Pic St. Jacques (24°58'00"S, 46°57'50"E) at 170 m, but from nowhere else (Emberton, in press). Thus a lowland species, known from only two widely separated localities in the southern Anosy and Vohimena Chains, within < 1000 km² of declining forest. Thus an Endangered species (IUCN, 1996).

Etymology: For the sharply (*L. acut-*) pointed spire (*L. apex*).

Parvedentulina margostriata Emberton & Pearce,
sp. nov.

(Figures 17, 18)

Streptaxidae sp. 10, Emberton et al., 1996:210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860802 (ex MBI 373.06DH, Tol-1, ad).

Paratypes: MBI 373.06DP (1 ad, 3 juv), MBI 373.06AP (8 ad [1 dissected]), MBI 374.15DP (1 ad), MBI 374.AP (1 juv), MBI 375.12DP (1 ad; AMS C.203450 [1 ad]), MBI 375.12AP (1 juv), MBI 376.10DP (2 juv), MBI 376.10AP (1 ad).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: northeast of village of Esetra: summit of Mt. Mahermana, 340 m: 24°26'12"S, 47°13'13"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 1.6 mm; height 3.6 mm. Height-diameter ratio 2.3. Whorls 6.1. Coiling tightness (whorl number divided by natural logarithm of shell height) 4.8. Apex angle 130 degrees. Spire angle 20 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 7.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.5 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 11.0. Apical sculpture faint, complete transverse striae after first 1.2 smooth whorls.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 54% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a

line between the columellar and upper peristome insertions) 1.0. Distance between columellar and upper peristome insertions is 69% of aperture width. Penultimate whorl projecting into body whorl; occupying 4% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 20 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture simple. Sutural notch density same as that of transverse ribs. Sculpture besides transverse ribs consists of faint spiral grooves, numbering 6 below whorl periphery.

Shell variation: Variation in coiling tightness makes some shells appear stouter than others: compare Figures 17 and 18.

Shell comparisons: Similar to *Parvedentulina rogeri* sp. nov., in which six whorls give a shell height of approx. 4.9 mm, but with a height of only 3.2 mm for the same number of whorls. The first embryonic whorl is proportionately smaller. Thus this species is like a two-thirds miniature of *P. rogeri*.

Description of lower reproductive system (MBI 373.06AP: 1 adult): Embryonic shell (whorl count not feasible) in oviduct. Anatomy otherwise unknown.

Distribution and conservation status: Known only from Mt. Mahermana, 100 to 340 m elevation. No reports elsewhere, not even from adjacent mountains (Emberton, in press). Critically Endangered, by IUCN (1996) criteria: single location, extent < 100 km², continuing decline in habitat.

Etymology: For the fine striations (*L. striat-*) on the whorl periphery (*L. margo*).

Parvedentulina esetra Emberton & Pearce, sp.
nov.

(Figure 19)

Streptaxidae sp. 11, Emberton et al., 1996:210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860803 (ex MBI 374.01DH, Tol-2, ad).

Paratypes: MBI 374.01AP (2 juv), MBI 375.13DP (1 juv), MBI 375.13AP (3 juv), MBI 376.11DP (1 juv), MBI 376.11AP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: northeast of village of Esetra: WSW slope of Mt. Mahermana, 300 m: 24°26'17"S, 47°13'10"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 2.2 mm; height 4.6 mm. Height-diameter ratio 2.1. Whorls 5.9. Coiling tightness (whorl number divided by natural logarithm of shell height) 3.9. Apex angle 130 degrees. Spire angle 25 degrees. Barrelling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 8.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.7 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 3.1. Apical sculpture smooth.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 56% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 65% of aperture width. Penultimate whorl projecting into body whorl; occupying 6% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 12 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture simple. Sutural notch density two-thirds that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: Very similar to *Parvedentulina rogeri* sp. nov. in size and shape, but lacking that species' distinctive apical sculpture, with a simple rather than shouldered suture, and with a less conspicuous but denser rib sculpture.

Distribution and conservation status: As the above, another Critically Endangered species (IUCN [1996] criteria) known only from Mt. Mahermana, 100 to 300 m elevation, and nowhere else, even on adjacent peaks (Emberton, in press).

Etymology: For the village of Esetra.

Parvedentulina apicostriata Emberton & Pearce,
sp. nov.

(Figure 20)

Streptaxidae sp. 12, Emberton et al., 1996:210. Emberton, 1997:1146. Emberton et al., in 1999:table 2.

Holotype: USNM 860804 (ex MBI 379.21DH, Tol-7, ad).

Paratypes: MBI 379.21DP (1 ad, 2 juv; AMS C.203451 [1 juv]), MBI 379.21AP (1 juv), MBI 383.17AP (3 juv), MBI 385.17AP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Mahialambo: ridge,

valley, and slope on southsoutheast slope of Mt. Ilapiry, 400 m: 24°51'27"S, 47°00'38"E; primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 2.1 mm; height 4.2 mm. Height-diameter ratio 2.1. Whorls 6.2. Coiling tightness (whorl number divided by natural logarithm of shell height) 4.3. Apex angle 135 degrees. Spire angle 25 degrees. Barrelling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 8.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.5 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 4.6. Apical sculpture faint, minute spiral striae.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 55% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 68% of aperture width. Penultimate whorl projecting into body whorl; occupying 6% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 11 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture simple. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: Most similar to *Parvedentulina rogeri* sp. nov. and *Parvedentulina esetra* sp. nov., but with much tighter coiling, a smaller first whorl, and apical spiral striae that are lacking in the others.

Distribution and conservation status: Mts. Ilapiry and Vasiha, known from 400 to 700 m elevation. No other known localities (Emberton, in press). Another Endangered species, with fragmented subpopulations within < 1000 km² of declining forests in the southern Anosy and Vohimena Chains, thus meeting IUCN (1996) criteria.

Etymology: For the apical (L. *apic-*) spiral striae (L. *striat-*).

Parvedentulina ovatostoma Emberton & Pearce,
sp. nov.

(Figures 21, 22, 23, 48)

Streptaxidae sp. 13, Emberton et al., 1996:209, 210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860805 (ex MBI 386.04DH, Tol-14, ad).



Figures 22–25

Figures 22, 23. *Parvedentulina ovatostoma* Emberton & Pearce, sp. nov., paratype, Tol-9 (Figure 22), and holotype (Figure 23). Figure 24. *Parvedentulina mahialamboensis* Emberton & Pearce, sp. nov., holotype. Figure 25. *Gulella minuscula* Emberton & Pearce, sp. nov., holotype. All scale bars 1 mm.

Paratypes: MBI 381.13DP (4 ad, 5 juv), MBI 381.13AP (2 ad, 4 juv), MBI 383.10DP (1 ad, 2 juv), MBI 383.10AP (3 ad, 1 juv), MBI 384.14DP (1 ad, 2 juv), MBI 385.12DP (1 ad, 2 juv; AMS C.203452 [1 ad]; MNHN [1 ad]; ANSP 400835 [1 ad]), MBI 385.12AP (2 ad [1 dissected], 6 juv), MBI 386.04DP (4 juv), MBI 388.08DP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: southsoutheast slope of Mt. Vasiha, 300 m: 24°55'37"S, 46°44'49"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 1.7 mm; height 3.7 mm. Height-diameter ratio 2.2. Whorls 6.1. Coiling tightness (whorl number divided by natural logarithm of shell height) 4.7. Apex angle 130 degrees. Spire angle 15 degrees. Barreling (outward departure from a straight line

of the whorls between $n-0.5$ and about the second whorl) 8.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.5 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 5.5. Apical sculpture strong, incomplete (sutural) transverse striae after first 1.1 smooth whorls.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 50% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 1.0. Distance between columellar and upper peristome insertions is 56% of aperture width. Penultimate whorl projecting into body whorl; occupying 4% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 11 in the seventh or eighth tenth of body whorl; rib height 0.01% of shell diameter. Strength of rib sculpture diminishing by about half toward apex. Suture simple. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell variation: There is great variation in the size of the first whorl and in coiling tightness, as demonstrated in Figures 21, 22, and 23.

Shell comparisons: Very similar to *Parvedentulina margostriata* sp. nov., but with looser embryonic coiling, slightly looser shell coiling, a conspicuously shorter callosus, rib sculpture only half as dense and diminishing toward the apex, and no spiral groove sculpture as in *Parvedentulina margostriata* sp. nov.

Description of lower reproductive system (MBI 385.12AP: 1 adult): Penis 0.9 mm long, 0.2–0.3 mm wide, but greatly constricted within sheath. Penial sheath present, 0.2 mm high, incorporating a loop of the vas deferens. Penial apical caecum absent. Penial general sculpture without pilasters, with a small but even field of medium-sized hooks, and with one giant apical hook and one giant basal hook. Penial retractor muscle attached at the penial apex. Epiphallus seemingly absent. Vas deferens slender at origin, insertion, and sheath, but swollen alongside the upper penis. Atrium size unknown. Spermathecal morphology unknown. Embryonic shell in oviduct 2.2 whorls.

Distribution and conservation status: Mts. Iapiry and Vasiha, 100 to 700 m elevation. Other localities reported (Emberton, in press): Mt. Mahermana (300–340 m) and nearby Mts. Teloboko (530 m) and Esetra (summit); and, to the north, Miaranony. Thus the species seems to occur in fragmented subpopulations within < 5000 km² of declining forest in the southern Anosy Chain, throughout the Vohimena Chain, and north to Miaranony. Therefore, by IUCN (1996) criteria, this is an Endangered species.

Etymology: For the ovate (*L. ovat-*) aperture (*L. stoma-*, mouth).

Parvedentulina mahialamboensis Emberton & Pearce, sp. nov.

(Figure 24)

Streptaxidae sp. 14, Emberton et al., 1996:210. Emberton, 1997:1147. Emberton et al., 1999:table 2.

Holotype: USNM 860806 (ex MBI 379.02DH, Tol-7, ad).

Paratypes: MBI 379.02DP (1 juv), MBI 379.02AP (1 juv), MBI 381.14DP (1 juv; AMS C.203453 [1 ad]), MBI 391.02DP (1 ad).

Type locality: Madagascar: Tulear Province: northwest

of Fort Dauphin: west of village of Mahialambo: ridge, valley, and slope on southsoutheast slope of Mt. Iapiry, 400 m: 24°51'27"S, 47°00'38"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 3.1 mm; height 6.8 mm. Height-diameter ratio 2.2. Whorls 6.8. Coiling tightness (whorl number divided by natural logarithm of shell height) 3.5. Apex angle 135 degrees. Spire angle 20 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 7.0% of shell diameter. Umbilicus (irrespective of columella) imperforate or nearly so.

Apex. First whorl diameter 0.8 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 1.6. Apical sculpture moderately strong, complete transverse ribs after first 0.7 whorls.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 61% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.8. Distance between columellar and upper peristome insertions is 70% of aperture width. Penultimate whorl projecting into body whorl; occupying 5% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 16 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture simple. Sutural notch density two-thirds that of transverse ribs. No other sculpture besides transverse ribs.

Shell comparisons: Similar to *Parvedentulina glessi* comb. nov. in size, shape, and sculpture, but with a conspicuously more tightly coiled and more broadly domed apex, much weaker sculpture, and an essentially imperforate umbilicus (perforate in *P. glessi* comb. nov.).

Distribution and conservation status: Mt. Iapiry, 200 to 400 m elevation. Emberton (in press) reports this species from Pic St. Jacques, the Midongy region, Manombo and environs, N of Manakara, and Kianjavato and environs (total elevational range 50–660 m), but not from the northern Vohimena Chain or from anywhere in the Anosy Chain. Thus *Parvedentulina mahialamboensis* sp. nov. seems to occur in extremely fragmented subpopulations within windward rainforest from north of Fort Dauphin to Kianjavato. This forest is continually declining and is < 5000 km² in extent, so *P. mahialamboensis* meets IUCN (1996) criteria as an Endangered species.

Etymology: For the village Mahialambo (east of Mount Iapiry), whose name means "skinny pig."

Genus *Gulella* Pfeiffer, 1856*Gulella reeae* Emberton & Pearce, sp. nov.

(Figures 15, 31, 34, 46)

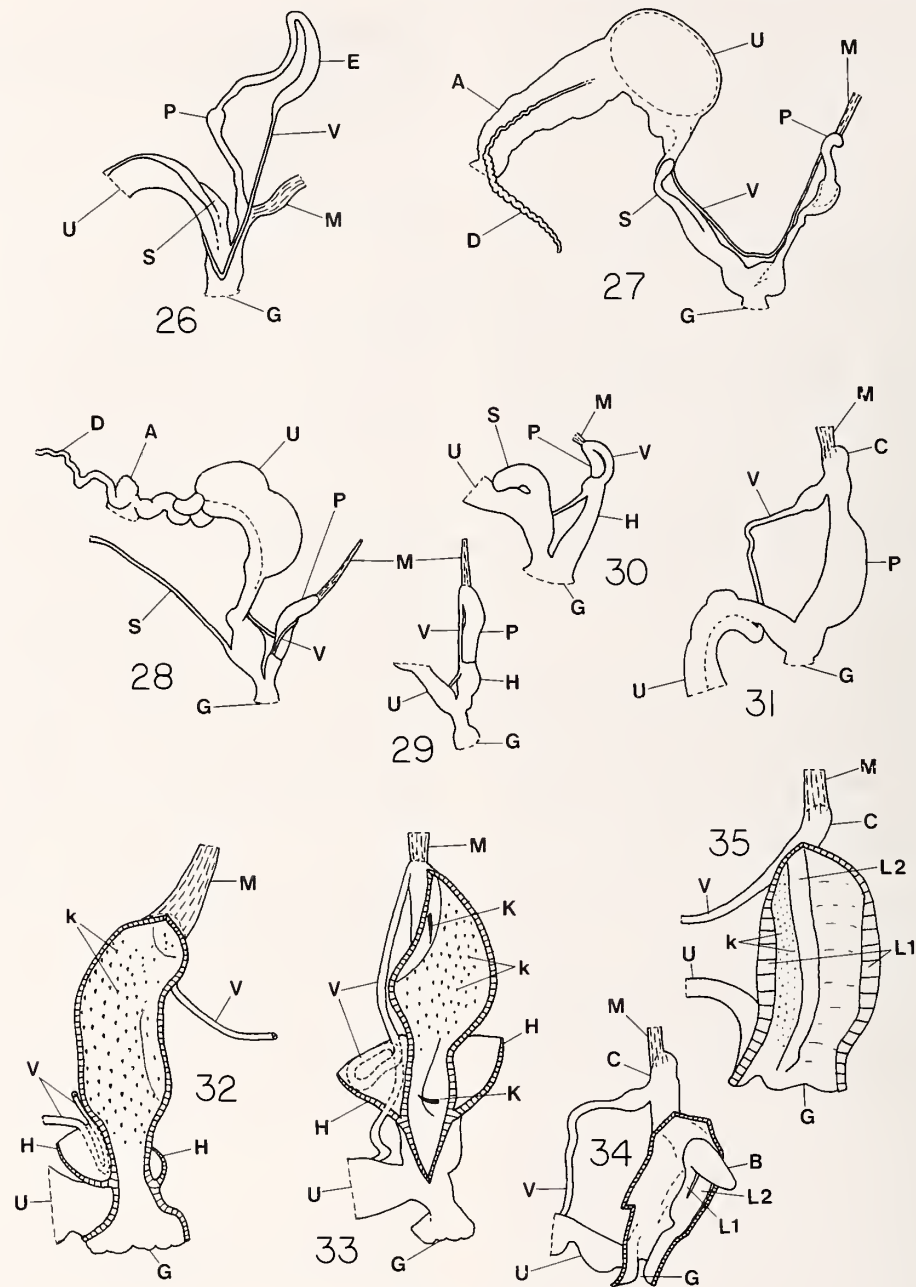
Streptaxidae sp. 7, Emberton et al., 1996:210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860807 (ex MBI 386.03DH, Tol-14, ad).**Paratypes:** MBI 381.12DP (1 ad), MBI 386.03DP (8 ad, 1 juv), MBI 386.03AP (2 ad), MBI 387.09DP (8 ad; AMS C.203447 [1 ad]; MNHN [1 ad]; ANSP 400833 [1 ad]), MBI 387.09AP (1 ad), MBI 388.07DP (2 ad, 1 juv), MBI 388.07AP (2 ad [1 dissected], 1 juv).**Type locality:** Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Malio: southsoutheast slope of Mt. Vasiha, 300 m: 24°55'37"S, 46°44'49"E: primary rainforest.**Description of holotype shell:***Shell Size and Shape.* Diameter 1.9 mm; height 4.3 mm. Height-diameter ratio 2.3. Whorls 6.5. Coiling tightness (whorl number divided by natural logarithm of shell height) 4.5. Apex angle 135 degrees. Spire angle 20 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 11.0% of shell diameter. Umbilicus (irrespective of columella) minute.*Apex.* First whorl diameter 0.7 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 5.5. Apical sculpture smooth.*Aperture.* Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 53% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.7. Distance between columellar and upper peristome insertions is 90% of aperture width. Penultimate whorl not projecting into body whorl. Parietal and palatal dentition present; columellar dentition absent. Columella strongly reflected and flat.*Shell Sculpture.* Transverse rib density 7 in the seventh or eighth tenth of body whorl; rib height less than 0.005% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture shouldered. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.**Shell variation:** No conspicuous variation in size or shape.**Shell comparisons:** Most similar to *Gulella miaryi* Fischer-Piette & Bedoucha, 1964, but with a much weaker parietal tooth, weaker sculpture, stouter shell, and—most importantly—shorter for more whorls.**Description of lower reproductive system (MBI****388.07AP: 1 adult):** Penis 1.1 mm long (not counting apical caecum), 0.2–0.3 mm wide at base and in upper third, bulging to 0.3 mm wide in lower two-thirds. Penial sheath absent, vas deferens free. Penial apical caecum present, 0.2 mm high. Penial general sculpture with two adjacent pilasters that run parallel in the upper half of the penis, then fuse to run as a single pilaster in the lower half; one of the upper pilasters bearing a large, tongue-shaped, pendant bulge. Penial wall otherwise without detectable sculpture. Penial retractor muscle attached at the penial apex and enveloping about half of the apical caecum. Epiphallus seemingly absent. Vas deferens broad at its departure from the prostate, then tapering and remaining slender until just before its entry into the penis, where it forms a bulblike swelling. Atrium medium in size. Spermathecal duct point of juncture with the oviduct uncertain. Spermathecal duct slender. Embryonic shell in oviduct 2.2 whorls.**Distribution and conservation status:** Mts. Ilapiry and Vasiha, 100 to 300 m elevation. Also reported (Emberton, in press) far north at Miaranony (21°10'05"S, 47°33'20"E), near the eastern boundary of Ranomafana National Park, at 630 m, but nowhere in between. Even if the Miaranony identification is correct and this species ranges continuously from Mt. Vasiha to Miaranony, its range is still < 5000 km² of fragmented, declining forest, meeting criteria (IUCN, 1996) for Endangered status.**Etymology:** For Ruth Elizabeth Emberton, K.C.E.'s mother, born 13 July 1922.*Gulella benjamini* Emberton & Pearce, sp. nov.

(Figures 14, 35, 43, 44, 46)

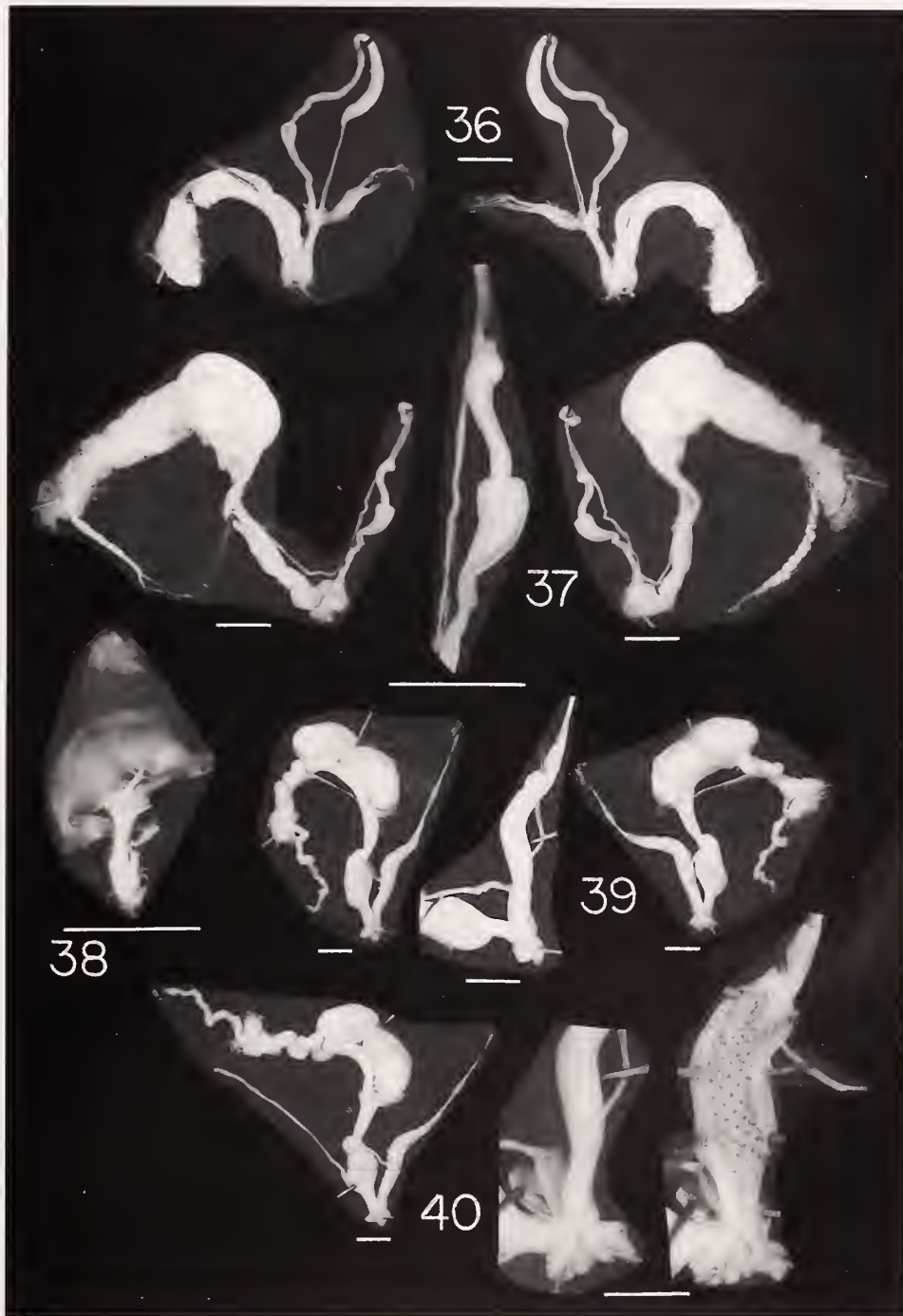
Streptaxidae sp. 8, Emberton et al., 1996:210. Emberton, 1997:1146, 1149. Emberton et al., 1999:table 2.

Holotype: USNM 860808 (ex MBI 381.05DH, Tol-9, ad).**Paratypes:** MBI 376.22AP (1 ad), MBI 377.14DP (2 ad), MBI 378.23AP (1 ad), MBI 379.20DP (1 ad; AMS C.203448 [1 ad]), MBI 379.20AP (3 ad [2 dissected]), MBI 380.13DP (1 ad), MBI 381.05DP (1 ad; MNHN [1 ad]).**Type locality:** Madagascar: Tulear Province: northwest of Fort Dauphin: west of village of Mahialambo: east-southeast slope of Mt. Ilapiry, 200 m: 24°51'39"S, 47°00'46"E: primary rainforest.**Description of holotype shell:***Shell Size and Shape.* Diameter 1.7 mm; height 3.2 mm. Height-diameter ratio 1.9. Whorls 6.0. Coiling tightness (whorl number divided by natural logarithm of shell height) 5.2. Apex angle 125 degrees. Spire angle 35 degrees. Barreling (outward departure from a straight line



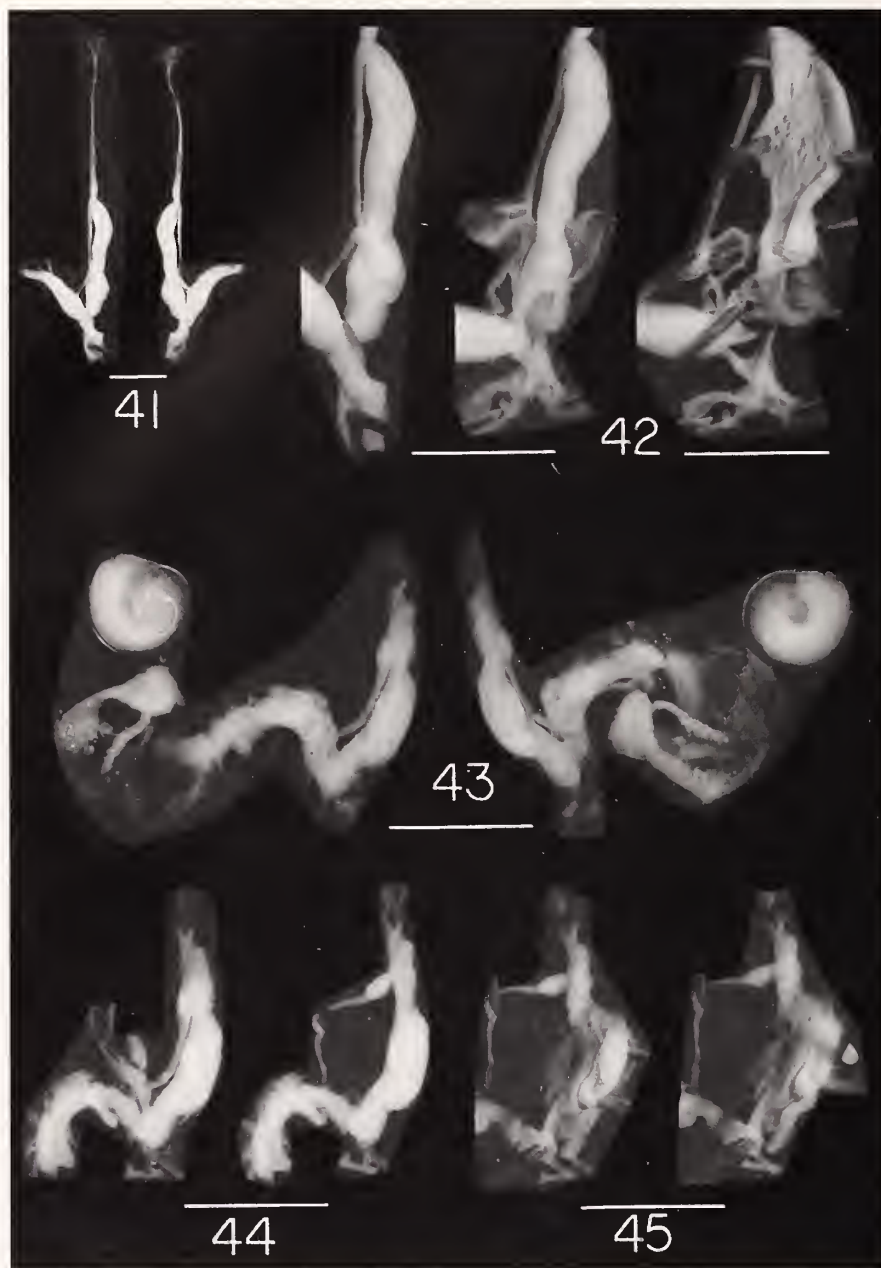
Figures 26-35

Reproductive characters labeled on tracings from photographed (Figures 36-48) dissections. Figure 26. *Fauxulus gaillardii*. Figure 27. *Subulina mamillata*. Figure 28. *Streptosteles latapex* Emberton & Pearce, sp. nov. Figure 29. *Parvedentulina rogeri* Emberton & Pearce, sp. nov. Figure 30. *Parvedentulina acntapex* Emberton & Pearce, sp. nov. Figure 31. *Gulella reeae* Emberton & Pearce, sp. nov. Figure 32. *Streptosteles latapex* Emberton & Pearce, sp. nov. Figure 33. *Parvedentulina rogeri* Emberton & Pearce, sp. nov. Figure 34. *Gulella reeae* Emberton & Pearce, sp. nov. Figure 35. *Gulella benjamini* (bottom far right). Dissected penial tubes (Figures 32-35) show cut surfaces crosshatched. Abbreviations: A - albumen gland; B - bulge on penial pilaster; C - penial apical caecum; D - hermaphroditic duct; E - epiphallus; G - genital pore; H - penial sheath; k - hooks (penial sculpture); K - giant hook (penial sculpture); L1 - penial pilaster #1; L2 - penial pilaster #2; M - penial retractor muscle; P - penis; S - spermatheca or its duct; U - prostate-uterus (sometimes enclosing egg or embryos); V - vas deferens.



Figures 36–40

Pulmonate reproductive systems and penes. Figure 36 (two views). *Fauxulus gaillardi* Fischer-Piette, Blanc, Blanc & Salvat, 1994. Figure 37 (three views). *Subulina mamillata* (Craven, 1880). Figure 38 (one view). *Opeas tsiveryi* Emberton & Pearce, sp. nov. Figures 39–40 (six views total). *Streptosteles (Makrokonche) latapex* Emberton & Pearce, sp. nov. All scale bars 1 mm.



Figures 41-45

Streptaxid reproductive systems and penes. Figures 41-42 (five views total). *Parvedentulina rogeri* Emberton & Pearce, sp. nov. Figures 43-45 (six views total). *Gulella benjamini* Emberton & Pearce, sp. nov. All scale bars 1 mm.

of the whorls between n-0.5 and about the second whorl) 15.0% of shell diameter. Umbilicus (irrespective of columella) imperforate or nearly so.

Apex. First whorl diameter 0.5 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 10.1. Apical sculpture faint, complete transverse striae after first 1.2 smooth whorls.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 42% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 0.9. Distance between columellar and upper peristome insertions is 86% of aperture width. Penultimate

whorl not projecting into body whorl. Parietal and palatal dentition present; columellar dentition present. Columella strongly reflected and flat.

Shell Sculpture. Transverse rib density 9 in the seventh or eighth tenth of body whorl; rib height 0.02% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture shouldered. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

Shell variation: No conspicuous variation in size or shape.

Shell comparisons: Very similar to *Gulella lubeti* Fischer-Piette, Blanc, Blanc & Salvat, 1994, but with more tightly coiled whorls, two fewer whorls (six instead of eight), and with transverse ribbing sculpture beginning at 2.0 instead of at 2.7 whorls.

Description of lower reproductive system (MBI 379.20AP: 2 adults): Penis 1.4 mm long (not counting apical caecum), 0.2–0.3 mm wide, tapered at apex. Penial sheath absent, vas deferens free. Penial apical caecum present, 0.3 mm high. Penial general sculpture with two adjacent, seemingly glandular pilasters that run parallel along the entire length of the penis; one of the penial-wall surfaces between them bears a sculpture of tiny chitinous hooks in regular array. The other penial-wall surface otherwise without detectable hook sculpture, but with faint latitudinal ridges. Penial retractor muscle attached at the penial apex and enveloping the entire apical caecum. Epiphallus seemingly absent. Vas deferens slender at origin and insertion and slightly swollen at mid-length. Atrium seemingly minute in size. Spermathecal duct joining the oviduct 0.6 mm above the atrium, hence the vagina is 0.6 mm in length. Spermathecal duct slender; length of duct plus spermatheca 1.6 mm.

Distribution and conservation status: Known only from Mt. Mahermana and Mt. Ilapiry, known from 100 to 540 m elevation. No other localities reported, even from other mountains in the Vohimena Chain (Emberton, in press). An Endangered species, restricted to isolated subpopulations within the approx 500 km² extent of rapidly diminishing Vohimena-Chain forests.

Etymology: For Dr. Benjamin Andrianamahaja, National Director, Ranomafana National Park Project, in grateful appreciation for his assistance and moral support throughout this and other projects.

Gulella minuscula Emberton & Pearce, sp. nov.

(Figure 25)

Streptaxidae sp. 15, Emberton et al., 1996:211. Emberton et al., 1999:table 2.

Streptaxidae sp., Emberton, 1997:1140.

Holotype: USNM 860809 (ex MBI 373.07DH, Tol-1, ad).

Paratypes: MBI 376.23AP (1 juv).

Type locality: Madagascar: Tulear Province: northwest of Fort Dauphin: northeast of village of Esetra: summit of Mt. Mahermana, 340 m, 24°26'12"S, 47°13'13"E: primary rainforest.

Description of holotype shell:

Shell Size and Shape. Diameter 1.1 mm; height 2.4 mm. Height-diameter ratio 2.2. Whorls 5.0. Coiling tightness (whorl number divided by natural logarithm of shell height) 5.7. Apex angle 125 degrees. Spire angle 15 degrees. Barreling (outward departure from a straight line of the whorls between n-0.5 and about the second whorl) 12.0% of shell diameter. Umbilicus (irrespective of columella) minute.

Apex. First whorl diameter 0.5 mm. Early coiling tightness (2 divided by natural logarithm of diameter of first two whorls) 12.0 (much greater than). Apical sculpture smooth.

Aperture. Aperture width (inside dimension, parallel to a line between the columellar and upper peristome insertions) 50% of shell diameter; height-width ratio (inside dimensions, height measured to and perpendicular to a line between the columellar and upper peristome insertions) 1.0. Distance between columellar and upper peristome insertions is 76% of aperture width. Penultimate whorl projecting into body whorl; occupying 6% of aperture height measure. Parietal and palatal dentition absent; columellar dentition absent. Columella slightly reflected.

Shell Sculpture. Transverse rib density 10 in the seventh or eighth tenth of body whorl; rib height 0.01% of shell diameter. Strength of rib sculpture not diminished toward apex. Suture simple. Sutural notch density same as that of transverse ribs. No other sculpture besides transverse ribs.

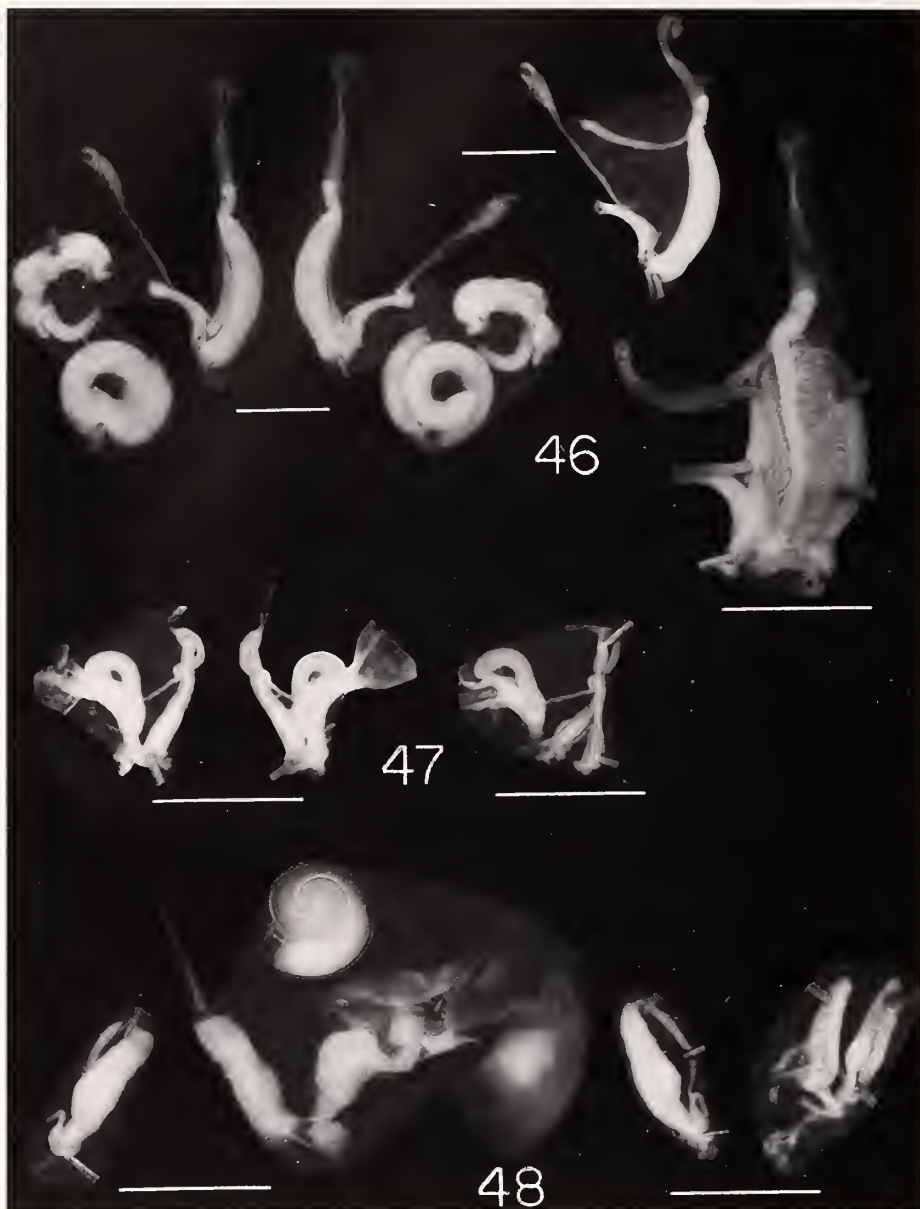
Shell comparisons: Unique within the genus for its minute size and narrowly protruding first whorl.

Distribution and conservation status: Known only from the summit of Mt. Mahermana, 340 m elevation. Not reported anywhere else (Emberton, in press). As detailed for other such species above, *Gulella minuscula* sp. nov. meets IUCN (1996) criteria as a Critically Endangered species.

Etymology: For the rather small (L.) size of the shell.

STREPTAXID CONSERVATION STATUSES

Analyses of individual species are given above in the species descriptions. To summarize, all 15 streptaxid species are proposed as either Endangered or Critically Endangered. The following five species should be listed as **Critically Endangered**: *Gulella minuscula* sp. nov., *Parvedentulina* gen. nov. *esetra* sp. nov., *P. margostrata* sp.



Figures 46–48

Streptaxid reproductive systems and penes. Figure 46 (four views). *Gulella reeae* Emberton & Pearce, sp. nov. Figure 47 (three views). *Parvedentulina acutapex* Emberton & Pearce, sp. nov. Figure 48 (four views). *Parvedentulina ovatostoma* Emberton & Pearce, sp. nov. All scale bars 1 mm.

nov., *Streptostele (Makrokonche) bougieformis* sp. nov., and *S. (M.) latembryohelix* sp. nov. The 10 species that should be listed as **Endangered** are: *G. benjamini* sp. nov., *G. reeae* sp. nov., *P. acutapex* sp. nov., *P. apico-striata* sp. nov., *P. mahialamboensis* sp. nov., *P. ovatostoma* sp. nov., *P. rogeri* sp. nov., *S. (M.) latapex* sp. nov., *S. (M.) magnapex* sp. nov., and *S. (M.) volhimenensis* sp. nov.

DISCUSSION

These descriptions of 20 small, high-spired pulmonates provide systematic support for our previous distributional and ecological analyses of Mahermana-Ilapiry-Vasiha land snails (Emberton et al., 1996, 1999; Emberton, 1997). A previous paper (Emberton & Pearce, 1999) identified the 25 caenogastropods, described their 22

small species, and analyzed their 17 species of *Boucardicus* Fischer-Piette & Bedoucha, 1965, for conservation statuses. In press are two additional papers describing the remaining Mahermana-Ilapiry-Vasiha pulmonates, and evaluating each charopid species for conservation status.

Streptaxids are a major, previously underestimated component of the Madagascan land-snail fauna. Previous to this paper, Madagascar's entire described streptaxid fauna numbered 30 species (Fischer-Piette et al., 1994; Emberton, 1994). Thus, collections from just three mountains, within a region representing less than 1% of Madagascar's total area, have increased Madagascar's described streptaxids by 50%. According to Emberton (in press:table 1), existing, identified collections from Madagascar include a total of 237 streptaxid morphospecies (far surpassing his earlier, pre-sorting estimate of 150 [Emberton & Rakotomalala, 1996]), and hundreds more species must survive in Madagascar that have never been collected.

Of the 88 land-snail species found by us on Mts. Mahermana, Ilapiry, and Vasiha, 15 are streptaxids. Thus, on average, streptaxids constitute 17% of the fauna. This is a high proportion of carnivores, but falls short of the astonishing prevalence of streptaxids in eastern Tanzania, for example, where they averaged about 25%, and where at one rainforest site they composed about half the species and a third of the individuals (Emberton et al., 1997).

Acknowledgments. We are grateful to the U.S. National Science Foundation and USAID for funding (grant DEB-9201060 to KCE); to staffs of the Ranomafana National Park Project, the Madagascar Département des Eaux et Forêts, and the Tolagnaro (Fort Dauphin) office of the World Wide Fund for Nature for logistical aid; to Roger Randalana and assistants from Esetra, Mahialambo, and Malio for collecting; to the late Felix Rakotomalala for curatorial assistance; and to Lucia Emberton for help in mounting the photographs.

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